2010

Assessing interpretability of visual symbols of varied colors across demographic profiles

Brendan Parker

Assessing Interpretability of Visual Symbols of Varied Colors across Demographic Profiles

By

Brendan D. Parker

Thesis Committee:

Dr. Anne R. Haake, Chair
Dr. Evelyn P. Rozanski
Dr. Robert J. Parody

Thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Information Technology

Rochester Institute of Technology

B. Thomas Golisano College
of
Computing and Information Sciences

March 22, 2010

Table of Contents

Literature Review: Research, Observations, and Background

Form and Function

Astute architect Louis Sullivan once stated that “form follows function” (Sullivan, 1901/1970, pp. 36-45). This has since created debate between artists and developers, arguing that one succeeds the other. Design is not a struggle between aesthetics and utility, but the two entities working together in order to produce a useful and desirable outcome (Fleming, 1998, pp. 70-71). Usability engineering employs artistic elements to serve a purpose. Icons are ornamental but are meant to represent and carry a particular meaning to improve communication.

Icons

An icon is a visual, abstract representation. In web and software development, designers create icons to signify an action or convey sufficient information in an easy-to-understand manner. These symbols can replace words and present ideas in less time and space. However, icons are not always self explanatory. Some are ambiguous, while others are intuitive. Some icons are used so frequently that they take on a particular, universal meaning.

Icons are meant to convey enough information efficiently. However, many visual representations are ambiguous. If designers have a way to measure how well an icon is understood, it may help improve the design flow and overall intuitiveness.

Icons are prevalent, necessary, and used in almost every discourse. They exist on traffic signs, bathroom doors, and in computer applications. Engineers use them to represent the variety of parts in a machine (Dreyfuss, 1984/1972, pp. 80-85). Architects rely on icons to convey plans (Dreyfuss, 1984/1972, pp. 48-53). Icons can attract attention as in a stop sign, effectively introduce unfamiliar concepts such as buttons on a machine or in software, or make a diagram fluent such as a resistor symbol. The problem with icons is that they are often ambiguous. Icons are designed to hold a particular meaning, but people may misinterpret them to mean something different. One example is the Beware of Lasers symbol (Dreyfuss, 1984/1972, p. 140). Some may mistake this to mean sparks or explosion. People are probably less likely to confuse the explosion logo to represent the laser, as they do not look alike (Dreyfuss, 1984/1972, p. 98). There already exists an accepted symbol that means “explosive,” which is similar to the laser icon.

Designers are usually assigned the task of creating interpretable images. Though the symbol may make sense to the developer, it may be unclear to users. The purpose of an icon is to improve intuitiveness of a system. If one interprets an image incorrectly, it fails to do its intended job.

Certain icons are designed so that they are globally understood and accepted. Such icons include a smiling face to represent “happy” or simplistic representations of widely used traffic signs such as an octagon to represent “stop” (Horton, 1994, p. 262). These were designed so that people from any background would be able to understand their meanings. These icons still require some learning, as people learn numbers and the meanings of objects such as traffic signs. Other icons are specific to a particular demographic. Geologists use patterns to label strata. Networking professionals draw plans using symbols for hosts, switches, and servers. Images that contain text might impose a language barrier such as the word “stop” on stop signs (which varies between regions) and the “P” symbol that represents parking. Some professions have different interpretations for the same image such as a horizontal thick line (Dreyfuss, 1984/1972, pp. 208-209). In mathematics, this symbol represents a minus sign for subtraction. It can also mean hybrid to biologists or even spores with female nuclei. It is also a sign that means “tab clear” to typists, and “earth” in astrology, and what hobos write on the sides of buildings to mean “doubtful.” This symbol represents something different in almost every context.

Often, icons acquire a meaning by being constantly associated with a particular application. People may use a certain shape or graphic to hold a specific meaning such as an octagon representing a stop sign. This shape for the sign originated in Detroit in 1914. The stop sign was not common, so it was assigned a shape that was more difficult to cut than more popular signs (Castro & Horberry, 2004, p. 19). Because of this decision, the octagon has become a widely accepted symbol for representing a demand to halt. If enough people use it, and the icon is used frequently enough in the same context, it will take on a particular meaning. While a gold star with rounded edges has a multitude of meanings, the American mindset suggests it has a specific connotation. Web developers and browser engineers have used this particular symbol to mean “favorites,” that is, a set of bookmarked websites that a user chooses to save and have readily available. This icon appears so frequently on the web that users may only accept this shape to mean “favorites” as the defacto standard. Some have gone as far as placing this symbol on their site with little or no explanation as to its meaning, expecting users to click on it to save their place on the web.

Icons are supposed to be easily recognizable by all without much training or background knowledge (Massironi, 1937/2002, pp. 260-264). Though many icons are designed for certain demographics and professions, there are rules and techniques that exist for developing icons that

several effective designs follow. Fundamentally, the icons that are written for a certain group are based on common inferred knowledge. A symbol depicting a subway car may be intuitive for people who live in the city but not as obvious to people who live in the country or in areas where public transportation does not exist.

Icons differ from pictures. In a picture, one tries to represent an object's uniqueness by preserving all details, no matter how small (Massironi, 1937/2002, pp. 260-264). An icon is designed differently, eliminating the finer details. An iconic representation is supposed to stand for a group, not an individual article. A picture of a man would not be an adequate symbol, as the details of the individual would make it seem like it is representing one person in particular. An icon would need to represent all men, so the details should be eliminated, leaving only the parts necessary to portray the shape as a man. An icon of a man may only consist of a head, body, and two long rectangles to depict the legs. This is a clear, understandable icon with high abstraction. People know it is a man without the particulars of race, eye color, height, weight, hairstyle, or other minute details. An icon is not a representation of an object, but a concept. It is an analogy, an abstract representation of something else. Icons are designed for simplicity to reduce cognitive effort in identifying the image, thus reducing the time it takes for recognition. An icon depicts few attributes, showing only the necessary factors to help one identify the icon.

If one were to describe an object or task foreign to another individual, the descriptions used to create the cognitive image could be the necessary particulars to show in an icon. In describing a telephone, what features are important to note? Possibly the general shape of the phone should be described. The button pad is probably the second most important. Seeing a three-by-three or three-by-four arrangement of square buttons on a device usually indicates a numeric pad. A telephone is one of the only devices with this feature, so people will instantly recognize it as such. This exercise will reveal appropriate ways to reduce the properties for proper depiction in an icon.

There are guidelines to designing a clear and comprehensible icon (Massironi, 1937/2002, pp. 260-264). Many icons such as those used in traffic signs, are usually composed of outlines drawn with regular shapes and mechanically constructed details. Usually, the shapes are unexpressive and rigid. The icons are usually centered figures against a flat background of high contrast, typically black on white. The orientation of the concept depicted is important and should be chosen carefully. Usually, the most expressive or different side is shown. A picture of a bicycle will show the side, not the front. A man would be seen from the front. Busses could be either the side or front. A coffee mug will usually be positioned on a profile so the handle is part of the silhouette. The viewpoint is typically at infinity. Icons do not usually depict depth unless absolutely necessary and usually show this by using overlaying symbols, not perspective. Icons typically

contain no amodal completion, transparency, or multistable patterns. The objects depicted in these icons are usually the most prototypical and distinguishable of their category. Though many telephones are now cellular, most would understand the meaning of a symbol depicting a wired touchtone or rotary telephone as opposed to the generic rectangular shape of a modern portable device. These are guidelines, not rules. They are not rigidly enforced among icon designers but are usually the best approach for most icons. The strategy for designing icons promotes a top-down interpretative progression that makes them easy to learn in an unconscious manner.

Images such as these are meant to serve a specific function, but, in time, are often adapted to have other meanings (Massironi, 1937/2002, pp. 260-264). The icons are abstract enough to stand for many possible concepts, although they were initially designed for one specific purpose. The symbols used to represent Olympic Games are examples. Originally, they were designed to show viewers where certain events were located or at what time they took place. Some of this icon library was adopted by the Olympic Committee as trademarks.

Characters

The earliest forms of writing were pictures. Cuneiform and hieroglyphics used pictures that were accepted to have intrinsic meanings. Strung together, these images could tell a story and record information. These pictographs eventually evolved into written characters, a faster and more accurate form of depiction. Words convey information but, unlike symbols, take up more space, do not grab attention, and often take longer to read. Using symbols instead of words for common expressions is usually an efficient alternative. The simplest icon can convey ample information. Characters are symbols with understood and accepted phonetics. Pictorial symbols are more ambiguous. In order to use symbols fluently, it is important to understand how people perceive their meaning. Semantics are the perceived meaning of a stimulus such as a word or image (Parkin, 2000/2000, pp. 113-114). This thesis will demonstrate how people perceive images by evaluating one's ability to classify an icon.

Many individuals have proposed ideas or attempted to create a universal writing system based on symbols. In the 1700s, the fiat of the Korean Emperor devised Korean Hangul, a writing system that used idiosyncratic amalgams. The current writing style uses Chinese characters to represent Korean sounds, an insufficient approach. The Emperor claimed that, "even a fool could learn [Korean Hangul] in a short period of time" (Marcus, 2003, pp. 37-43).

Pasigraphy is the practice of using globally recognized systems as a form of language (Marcus, 2003, pp. 37-43). Theorists believe that some form of pasigraphy will become a worldwide writing

style. Recent innovators have proposed styles that contain systematic approaches to representing much of the same syntactic elements as modern languages such as nouns, verbs, and adjectives. Recently, innovators Charles K. Bliss and Yukio Ota sought to develop a visual form of Esperanto, a formerly proposed language that was meant to have global acceptance and understanding (Marcus, 2003, pp. 37-43).

Understanding and Interpreting Form

An understanding of gestalt (German for “shape”) is necessary if creating a meaningful and interpretable set of icons. Gestalt explores fundamental concepts of graphic development based on psychological research. The brain takes abstract designs and finds similarities among them. Gestalt principles explore this phenomenon using the concepts of similarity, continuity, closure, proximity, and the relationship between figure and ground. Similarity is the concept of finding unity in objects that look alike. A square amongst a crowd of triangles would stand out. Continuity controls where the eye moves across a static image and gives an idea of where it would move next. A picture of a bouncing ball in midair with motion lines would tell the viewer where it came from and where it is going. Closure uses the mind’s ability to create the whole from parts and piece together a series of shapes into something complete. An artist does not have to draw every line on an image before the audience will recognize it ("The Gestalt Principles," n.d.). The World Wildlife Fund logo depicts a panda using simple shapes that the mind interprets as a whole (World Wildlife Fund, 2006). Proximity unites elements that are close to one another and gives the impression that they have related properties. A website may contain two groups of similar looking buttons, but one set links to pages within the site and the other to external sources. The relationship between figure and ground shows that a shape can be identified either by the “black” or “white” components. A common example is a symmetrical picture of two black silhouettes facing each other on a white background. The viewer can either identify the black symmetrical faces or the white vase-shaped object. Exploring these psychological principles can help in designing the interface ("The Gestalt Principles," n.d.).

Gestalt has a significant effect on how one perceives an image. The observer may see a shapeless figure but interpret it to have meaning based on the principles of visual cognitive science. The brain tries to make sense out of everything by piecing together information fragments into a whole. Therefore, when one looks at an icon, the brain interprets strokes of varying contrasts to represent a particular shape.

Sometimes gestalt is present in subjective organization patterns such as in games. Some board games like Go and Go-Moku require the user to develop perceptual models in order to play and interpret the game effectively, as illustrated in Figure 1. This model will vary depending on the rules for the game. Go and Go-Moku have a similar layout and style; they are played on the intersecting grids of a 19x19 board, and players alternate placing black and white stones on the vacant sections ("Go," 2008). Despite their similarities, they are played quite differently. Go requires the players to surround each other's pieces with their own to capture. Go-Moku requires players to place pieces on the board until one player forms a line of five with his or her own color. The games may look the same while playing, but the players perceive each game differently. Depending on the game, certain pieces become the focus and strategies change (Norman & Rumelhart, 1975, pp. 308-346).

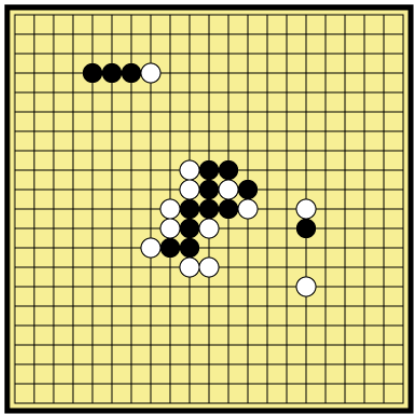


Figure 1 – Go and Go-Moku

A game of Go in progress. A player would use a different perceptual model if playing a game of Go-Moku. What would your next move be if you were playing one game as opposed to the other? How would your conceptual models differ?

Gestalt is a necessary factor in the ability to interpret the games. Proximity assists in identifying critical pieces. Plays made close to the area of focus are more noticeable than those at a distance. Continuity states that pieces in a line or organized pattern are easy to detect and remember. In both Go and Go-Moku, identifying contiguous pieces is critical. Similarity makes it possible to easily identify groups of similar pieces (Norman & Rumelhart, 1975, pp. 308-346). Noticing a group of white in Go may inspire the black player to want to surround the group. In Go-Moku, the black player would be wary of a large white group, as victory may be imminent.

The brain is capable of storing information regarding previously observed images. When one sees an object for a second time, the brain checks this bank of stored information and recalls an image that has similar properties (Edelman, 1999, pp. 1-10). An observer may view a drawing of a boat and recognize it by its distinct features: a hull, triangular sails, and maritime background. The observer may recall the same information if looking at a triangle atop a half ellipse. Since the shapes are similar, the brain makes the connection. This gives meaning to abstract images.

The brain may easily identify the image but not be able to recall what the image represents (Edelman, 1999, pp. 1-10). An example is the observer looking at a circle. There are many objects with a similar shape, and the observer usually will not draw a confident solution of what the circle represents. Even if the user is knowledgeable of the context (such as the beach), a circle can still represent a beach ball or the sun. The observer may seek other cues to identify the ambiguous shape. If the circle is above the person, it may be the sun. If the person is holding it, it may represent a beach ball.

Failure to properly recognize an image can cause ambiguity when interpreting its meaning. Joseph Jastrow's 1899 image is a strange figure that looks like either a duck or a rabbit. Because the observer cannot confidently recognize the image, there is a failure to recall (Edelman, 1999, pp.1-10). The person knows what a duck and a rabbit look like yet cannot immediately distinguish which of the two the image represents.

The visual cues in the duck and rabbit such as the eye, ear, bill, and direction of feathers or fur ultimately lead to the decision the observer makes about the graphic. In fact, visual cues can make sense out of the most abstract objects. If one makes a scribble on a sheet of paper, it may not look like anything apparent (Massironi, 1937/2002, pp. 216-221). However, if two visual cues—a small isosceles triangle and a circle of almost the same area—are positioned correctly on this scribble, it may take the shape of something familiar. As seen in Figure 2, the scribble seems to take the shape of a bird. If one is to observe image A, they may say it looks like nothing but a scribble. If viewing image B, they may say it looks like a bird, chicken, or something similar, just by recognizing the extra visual cues. This psychology is why viewers can usually make sense of abstract artwork such as works by Picasso.

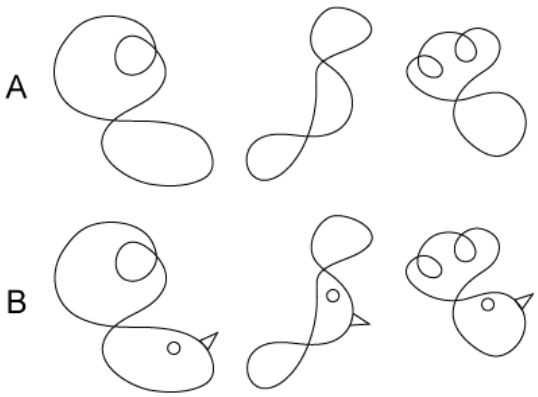


Figure 2 – Abstract Birds

Scribbles may not look like anything particular. If visual cues are added to the scribbles, they become recognizable figures. B contains the same scribbles as A, but one may recognize them as birds.

Understanding a symbol is a conscious effort. When one sees an object such as a ball, it is interpreted as being more than just red and round. Piecing together these components and including some logical reasoning give the different stimuli and details meaning (Newton, 1995, pp. 91-96).

Elements of Graphic Design

There are seven elements of art: form, line, shape, color, texture, space, and value. Each is an important concept in the creation of icons and symbols and should be investigated to gain a thorough understanding of the basics of design.

Basic design elements such as spots, lines, and simple shapes are capable of expression (Bates, 1949). Understanding the psychological interpretations of varying forms offers the designer greater insight. Simple spots are capable of conveying a multitude of expressions depending on their position, size, shape, color, and texture on the canvas. Proximity matters as well. For example, two spots are separate from each other at a distance greater than their diameters are seen as far apart. If they happen to be in proximity less than their breadth, they are near each other. Icon designers can use this innate philosophy to convey a distance factor through icons.

Form

A form is a three-dimensional figure that takes up space. Since the icons in this thesis exist only in two dimensions, this principle does not directly apply. However, an understanding of form is necessary for graphics that contain shading, perspective, or perceived depth. These elements are covered later in this section.

Line

A line, in its simplest form, is the element formed by moving a point along an area. Lines can exist in either second or third dimension. They can either be a mark such as something drawn on a canvas, an object such as wire, or implied such as the edge of an object. Typically lines are used to mark the border, contour, or silhouette of an object.

The line is considered the most useful of all graphical elements, as it can take virtually any form and represent many figures (Martinez & Block, 1988, pp. 136-152). Even children can surmise the power of lines. Lines allow an artist to convey an image using the abstraction to arbitrate between figure and space.

Curved lines indicate movement (Bates, 1949). If an icon should represent a changing or dynamic principle, it may exhibit wavy lines. Even if a designer is attempting to convey a straight movement or steady progression, curvy lines may best represent the transition. These lines make the viewer feel there is movement. Though using a straight line is a logical first approach, the icon may best represent the intended meaning through curved lines. Lines can also invoke an impression of speed. “Fast” lines typically have slight curvature, and “slow” lines usually have sharper curves that occur more frequently. Variations in thickness, contrast, and manipulation can give a sense of depth or lead the eye along a certain path. Lines also have the capability to evoke emotion. With many predictable curves, a line is seen as “sweet” and “calm,” and usually relaxes the viewer. Sharp, overlapping lines can suggest unrest and make the viewer nervous. Invoking emotions is another skill a designer should master, as it can be a useful tool in icon development.

Signatory lines are strokes with organic form varying in intensity, thinness, weight, and darkness (Martinez & Block, 1988, pp. 136-152). The lines are usually freeform and hand-drawn and usually nonreplicable. They are called signatory, because when one writes, the scribe creates lines with the same style. The expressive lines can also convey an artist’s style and originality.

If a line is deemphasized and stripped of the individual and expressive qualities, it becomes an impersonalized expression (Martinez & Block, 1988, pp. 136-152). An impersonal line can be straight or organic and have the same curvature as a signatory line. The element is the same throughout, not varying in intensity, thickness, or other property. They are crisp, clean lines, similar to ones found in a technical portrayal.

An implied line is not visible (Martinez & Block, 1988, pp. 136-152). It is a perceived interpretation of an arrangement of elements in an area. An arrangement of notes on a stave or spots on a canvas may create an imaginary line derived from their patterns. If an artist were to wet a brush with paint and swing his arm, creating a series of splatters on the canvas, the spots may be arbitrarily arranged linearly. They would appear to form a line, and the viewer would perceive the arrangements of splatters as a path. A practical application is a best fit line on graphs where each datum governs the shape and direction of the resultant.

Contour lines border a silhouette (Martinez & Block, 1988, pp. 136-152). They represent the edges of a figure and are typically used to differentiate between shape and background. The contour can convey an image or shape in very few lines. It is a simplistic representation of form. A caricaturized icon is typically made of contours. Small icons are typically more simply drawn than larger and usually contain simple shapes and images. They too are usually made of contours, as

caricaturized images are easy to see when the symbol is at low resolution or occupies a small area in the field of view.

Shapes

A shape is an enclosed space created by various other elements of art. Shapes should be kept simple. They should express, not necessarily represent. If a shape is too complex, has too many curves or edges, or leads the eye in various directions, it may not exhibit the intended meaning (Bates, 1949). Simplifying shapes make them more understandable and interpretable. Emphasis may also be necessary to convey something. If a symbol represents a car, it will not show the antenna, muffler, rearview mirror, or any other small details that are associated with the car. Instead, the image may be an overly simple body with big wheels. This simplifies the minor details by making the entire car body one shape and emphasizes the identifiable characteristics such as the wheels.

Shapes are typically easy to distinguish and are a simple, primitive method for communication (Martinez & Block, 1988, pp.118-133). Shapes have visible personalities and are considered to be a universal language. In marketing, shapes may create an identifiable corporate brand. Aesthetically, they help convey messages and emotions. In short, a shape is a visible representation of forces in an area.

Though many shapes are clearly identifiable with noted perimeters, others are implied (Martinez & Block, 1988, pp.118-133). A structural skeleton allows a viewer to see a shape from a pattern of dots or an arrangement of line segments. This draws upon the concept of closure, as the brain tries to make sense of several pieces of information. A mess of points arranged in a circular shape may be difficult to decipher, but identifying the series of dots as a circle is a way of making the pattern clear and distinguishable. The ability to identify shape will determine whether the figure is simple or complex. Simple shapes have easily identifiable patterns and are usually replicable through memory such as most geometric shapes. Complex shapes are not as clear or memorable. The structure is more difficult to determine and may take more cognitive processing for the brain to develop a clear interpretation of the shape's form. To quickly convey messages such as an icon to viewers of different backgrounds and cultures, simple and memorable shapes are best. Contrarily, a complex shape may keep the viewer's attention longer and is sometimes preferred for artistic appeal.

Another factor to consider in the learnability and memorability of shape in icons is the geometry itself (Martinez & Block, 1988, pp.118-133). A geometric shape is a clearly defined, crisply drawn

figure that follows a set of predetermined. Angles, straight edges, and measured curves are necessary to make such a construction. The most common geometric forms are the circle, square, and equilateral triangle. Each has a set of clearly defined properties and is perfectly represented to match other forms of its kind. They are governed by mathematical rules, rigid, absolute, and universally understandable. Organic shapes are more natural in appearance. They can contain curves, smooth edges, varying angles, and any intermix of form. These shapes match forms typically found in nature and do not obey a particular structure or arrangement. These curved free-flowing figures are more difficult to memorize.

The three simple shapes—square, triangle, and circle—can make up most other forms (Martinez & Block, 1988, pp.118-133). Though many figures can be composed of these simple shapes, the shapes themselves cannot be simplified. Some figures are made from variations of these primitives. This variation is described as tension. Stretching, skewing, or transforming the shape in any way will give it a different appeal and may hold a different meaning. This may affect icon interpretability, as subtle deviation in shape can change the visual's characteristics. Though a square may appear solid and secure, tilting it on its corner and stretching it may give the appearance of movement and instability. This could prove useful in icon design.

Weight is a subjective assessment of how light or heavy a certain shape appears to the viewer (Martinez & Block, 1988, pp.118-133). Geometric figures appear to have more weight than organic. A regular geometric form such as a square will seem to have less weight if the edges were slightly curved and angles did not match. An organic version of the form would be lighter than its regular counterpart. Symmetry is also a factor, as objects that are symmetrical seem to have more weight than those that are not. Objects in the center of a composition also appear to have more weight.

When a single shape is added to a field, it results in two forms (Martinez & Block, 1988, pp.118-133). The figure, or positive shape, is the shape itself and typically the focal point. The ground, or negative shape, is the area around the image that now has a distinct shape, as the added figure has cut away from it.

Color

The color element has three properties: hue, intensity, and value. The hue is the type of color such as red, green, orange, and blue. The intensity is a measure of brightness and dullness. The value is how light or dark the color appears. The philosophy and phenomenon of color is described in detail later in this section.

Texture

Texture in art is typically a description of surface properties – how a surface looks or feels. Typically the texture is referred to a physical object such as a sculpture or model but can also apply to graphic design in a sense of a pattern or face. A texture usually fills a shape or area, changing the property of the surface.

Textures have tactile qualities (Martinez & Block, 1988, pp.64-65). In its intangible form, texture communicates a sense of feeling through visualization. The phenomenon also allows a viewer to develop a sense of the physical properties of a shape such as weight, speed, roundness, and solidity. A surface with more texture seems slower, and the viewer may appreciate the more subtle details in the figure. The eye will move slowly across these surfaces. Publications are also dependant on texture to improve readability. The variations in text sizes, fonts, weights, and other typographical elements will improve organization and understandability of the whole piece.

Space

Space is the distance between or the area around figures. In a figure-ground relationship, the ground can be classified as space.

A flat area is perceived differently from the realism of a three-dimensional world (Martinez & Block, 1988, pp.68-103). The mind attempts to perceive the element of space whether the image is depicting a realistic scene or is an abstract arrangement of flat figures. All shapes have a position on a surface. When elements overlap, they are either above or beneath the others. Overlapping objects can lead the eye across a certain path, create focus or emphasis, or help group elements to suggest similarity. It also shows which objects are in front and which are in back.

Overlapping refers back to the figure-ground phenomenon where one object is the foreground and the other the background (Martinez & Block, 1988, pp.68-103). This is typically left to the subjective viewer's interpretation such as a dark circle on a white square. The circle is either dark and in front of the square, or the square bares a hole, revealing a dark object behind. Though the classification of a shape as a figure or ground is typically left to interpretation, there is psychological and physiological justification for why a viewer will identify them as such. Both figure and ground shapes have particular characteristics and work separately in visual configuration. Figures typically look heavy, mobile, and self-contained. Figures also tend to have convex shapes and protruding parts. Textured elements are also seen as the figures in a piece.

The figure may not be a complete shape. Lines can qualify as figures. The closer the lines are, the more they will look like a complete figure. If they are far apart, they may appear as the background. The backgrounds usually look empty, smooth, and lacking texture. They are typically lighter in appearance and may spread over a large area or throughout a piece.

Gradients are an effective tool for creating space (Martinez & Block, 1988, pp.68-103). A gradient is a gradual change in a visual quality, typically shading or color. The change is subtle and usually happens in a series of steps. Each step is gradual so that it does not appear coarse, and the eye is able to transition smoothly without saccades. Gradients can illustrate depth and also make elements more apparent as figure or ground.

Variations in size and position on a page can assist in spatial illustration (Martinez & Block, 1988, pp.68-103). Objects situated higher on a page will appear further in the distance. This is because most visuals illustrate closer objects toward the bottom of a canvas. The perceived size is dependent on the surrounding figures. Shapes in the background are typically smaller than those in the foreground. In nature, far away objects appear smaller than those that are close. The observer applies this perception to flat art. To keep the image consistent, many artists use vanishing points to help determine the position, size, shape, and orientation of figures in the picture. The vanishing point is an imaginary point to which all elements will converge when positioned farther away from the viewer.

Isometric compositions are drawings that do not have a vanishing point, as distance will not affect size or shape (Martinez & Block, 1988, pp. 68-103). All parallel lines will remain parallel regardless of distance or orientation. The Illustrations are highly geometric and often simplistic. Many technical fields adopt this style to convey blueprint ideas. Architecture and engineering fields rely on these drawings to convey plans in a clear and simplistic manner.

Value

The element of value is the darkness or lightness of a surface. It is typically used to represent volume, reveal the presence of a light source, and add realism to depth. Variations in shade are often the result of a light source.

Modifications to an object's appearance such as scale, rotation, and color appear as such because of the objects surrounding it (Martinez & Block, 1988, pp. 170-181). This is also true with value. Objects look light and dark compared to the shade of the objects around it. This is known as the concept of relative value. Darker colors appear heavier and smaller than lighter colors. A

white circle may seem less dense and may appear to 'radiate' light, making it look larger. A dark circle will look more strong and secure.

A difference in contrast can change the impression one visualizes in an image (Martinez & Block, 1988, pp. 170-181). Some shading styles are high contrast, meaning there is a great distinction between the lightest and darkest points on an object. Typically, this style is not gradual. This hard-light appearance leaves the viewer with the impression that the object is more solid. It appears as more legible and visible and the three-dimensionality is more apparent. Objects of less contrast usually have a soft-light appearance with a minute contrast between the dark and light areas.

While surfaces that are distinctly black, white, and gray look solid and secure, surfaces that have tonal gradients appear to have more volume and potential to convey other expressive features (Martinez & Block, 1988, pp. 170-181). A tonal gradient is a transition to a light or dark that has the power to lead the eye in and out of the picture and guide it along a certain path. As previously noted, gradients can add a feeling of depth. The variation from dark to light can create a three-dimensional effect. This is useful for developing icons that need the appearance of depth such as buttons and may add more realism to the image where necessary.

Principles of Graphic Design

The principles of art accompany visual iconography. While the elements of graphic design typically refer to the primitive structures of form, principles hold more philosophical and subjective concepts. Elements are easier to measure and have a more objective meaning and interpretation. The principles of graphic design are emphasis, balance, harmony, variety, movement, rhythm, proportion, and unity.

Emphasis

Emphasis is the concept of drawing attention or attracting the eye. In a composition, this can occur in a multitude of ways. Figure size, shape, color, texture, or placement can draw the viewer's attention. Artists can change the color or texture in order to create emphasis. Adding more detail to certain parts of a picture forces the viewer to observe these sections for a longer duration than the rest of the piece. Another strategy is to reduce emphasis on certain regions to move the viewer's attention to other areas. Drawing faceless characters or using simple shapes are ways to decrease detail and focus attention on other areas (Massironi, 1937/2002, pp. 71-77). An artist caricaturizes certain icons or symbols to emphasize attributes. To illustrate loudness or

sound, an image of a horn may contain a larger mouth. A car may be drawn at a slant to indicate speed. A button in a series may have a different color from the rest to attract attention.

Balance

Balance is the concept of maintaining an equal feel throughout the piece and is usually accomplished through symmetry (Martinez & Block, 1988, pp.18-19). One side of an image may have similar qualities to the other. Balance does not necessarily need symmetry. Balance is usually achieved when the canvas appears to have equal "weight." This can be based on any property, especially size, color, shape, position, value, and texture. Using similar shapes throughout or in a predictable pattern may help attain this property. Having a light- colored piece at the top and bottom, or a large, mildly light piece at the top and small, very light piece at the bottom, can establish a balanced image. This is not a rule in art, as unbalanced images can be just as attractive and desirable as balanced images. Regardless, this is a very profound and useful concept in the design of visual symbols.

Harmony

A harmonious image appears to have a similar look and feel throughout. Harmony is the idea of using a predictable pattern or giving a simplistic look to an image. No part of the image stands out above the other. A harmonious picture has little-to-no emphasis and a high sense of balance. A chess board and most wallpaper are examples of harmonious design.

All visuals have a certain feel, whether happy, sad, confusing, ordered, heavy, or light (Martinez & Block, 1988, pp.16-17). This medley of visual forces is typically referred to as harmony. Similarly, this term is used in music and describes how notes played together have a certain sound and feel. Like notes, groups of artistic elements work well together. Combinations of arranged shapes, colors, patterns, and properties give a feeling of completeness to the work, expressing a certain quality and character.

Variety and Unity

Though antonymic, unity and variety function together. Unity refers to the completeness of an image and the appearance that it is a whole. This is particularly important in icon development. Many icon designs are developed in a way so that one icon looks like two. Conversely, there are many instances where two separate icons appear as one. To avoid such confusion, icon designers may put a box around the graphic, use a line as a break, or bevel the area in which

each icon is supposed to exist. Variety is a measure of difference throughout the visual piece. Using a variation of shapes, color, textures, and style can give the image more variety.

Unity is the measure of repetition and order, and variety is a lack thereof, incorporating more asymmetry and disorder (Martinez & Block, 1988, pp.10-41). It is not a rule that a picture must follow either principle. Most compositions are a combination of both. Typically symmetrical images have more unity, as they follow a predictable set of guidelines. Contrarily, asymmetrical images have variety. Unified images are typically made from straight shapes and lines.

Clarity and ambiguity can change depending on the amount of unity and variety in a picture (Martinez & Block, 1988, pp.10-41). Regular shapes seem to have order and predictability, but irregular shapes usually do not. The brain tries to deduce what an image is trying to represent. If a square had an edge that was slightly skewed, the viewer may be confused trying to decide whether it was a square or a trapezoid. This type of visual is different from the clear application of tension. This is described as ambiguity, and the process by which the brain tries to decipher the image is called leveling and sharpening.

Movement

Movement guides the eye throughout the image and can express movement and action. This is probably the most profound principle of design, as it is more of an interpretation than a mere observation. Movement exists because the viewer perceives the image to have such a property. Lines, fades, and the way an object is shaped can all express movement. Such expressions are used in comics where motion lines represent a change in position. Such properties are useful in icon development because symbols may need to illustrate movement in order to convey a certain message. Contrarily, some icons may be mistakenly interpreted to represent movement when the lines and shapes are meant to show something else.

Pictures can illustrate movement (Martinez & Block, 1988, pp.154-167). A person sitting or running can each appear to have movement of some sort even though the latter is more dynamic. A photograph of a jogger sprinting may or may not appear like the athlete is moving depending on the position. Movement in pictures is not a capturing of moving objects but a perceived sense of dynamics through shapes. Tension represents movement. The angle and stretch of a shape in an image can make it appear active. Changing the properties and elements such as thickness of a line, direction, color, shape, or the gradient can imply movement. Disorder and asymmetry appear to have more movement than ordered, rigid objects. Shapes that appear to align with a vertical and horizontal are seen as stagnant and secure. A graphical depiction of a windmill will

traditionally have four blades arranged in a regular cross pattern. If the blades are aligned like a plus sign, the windmill will not seem like it is in motion. If the blades are arranged in the shape of an “X”, they will seem more dynamic, but the viewer will see an imaginary box connecting the ends of all blades that form a regular square. In order for the blades to appear as though they have movement, they should be at an obscure angle, somewhere between the plus and “X” patterns described earlier. Some icons also take a stroboscopic approach to motion, which shows an image changing over a distance similar to the common evolution picture. Movement is an important technique for a graphic artist to master in order to create visually sound symbols.

Many artists employ the method of showing a sequence to represent scientific events such as the lifecycle of a mosquito (Massironi, 1937/2002, pp. 196-197). Such drawings can illustrate a metamorphosis, revealing each stage in a lifecycle. Since each phase is significantly different from the others, one may not believe it is the same creature if seen separately. Mosquito larvae bear almost no resemblance to their mature counterparts. Arranging such a visual description in this manner shows the perplexing changes that the insect experiences to become what it is as an adult.

Cognitive drag is also a factor in interpreting sequences (Massironi, 1937/2002, pp. 198-204). This principle discusses the idea that the brain can see relations in objects in a pattern. If a circle were placed next to a square, they would seem to be two different shapes. If a circle were placed away from a square, with a group of images between them illustrating the shape of the circle gradually changing into the shape of the square, it would appear that one shape has turned into the other. The amount of change between each shape determines how it is interpreted. More intervals illustrate a richer, slower change that provides more information to the viewer.

This is, in a sense, a way of showing animation without time. Time is not an actual determinant of change but a perceived, subjective value. Viewers get an impression of a change over a period of time.

Rhythm

Rhythm is typically a property of movement. In an image, rhythm is a pattern. Usually it is a repetition of a certain shape, color, or other visual property. It can be a variation of lights and darks or a predictable assortment of texture.

In music, rhythm is a way of dividing and shaping the melody (Martinez & Block, 1988, pp.32-33). Rhythm relates to time in music and space in art. Usually, rhythm is seen in repetition or lack

thereof. A missing dot may be difficult to miss in a random mess of one thousand others, but arranged in rows and columns, the missing dot will stand out. This is because the rhythm is broken. Repeating shapes, color patterns, or intervals can alter the rhythm of a piece.

Proportion

Proportion describes the size or scale of an object. Typically the proportion is subjective and is in relation to the image as a whole, other objects within the image, or other objects adjacent to the image. In icons, designers typically use a separate shape that remains a constant size to illustrate proportion among a library of icons. Such an instance is the illustration of a thermometer that has a darker shade inside the outline, showing various grades.

A proportional system designates the rules of scale (Martinez & Block, 1988, pp.38-40). The artist is allowed to vary objects according to these rules. If the guidelines are broken, a character could have a longer than normal arm or a building could be absurdly top heavy. Artistically, such variation is welcome, despite natural defiance. Designers could use such a principle to emphasize certain features or characteristics of an image, thereby making it easier to interpret and more memorable. Inappropriate use could also confuse the viewer; as such a distorted object may make identifying the symbol difficult. Though there is no one rule for constructing acceptable proportions, many cultures have devised their own paradigms. Greeks used a ratio called the Golden Section, where two lines (a larger and a smaller) are summed to equal an even longer line. These three measurements would then be used to form structures such as a statue, where the measurements would make up the torso and legs. Japanese rooms were modeled after Tatami mats that would serve as the floor. Each mat had 2:1 dimensions, so the longer side would be twice the length of the shorter. These mats could be arranged to construct rooms of various sizes as long as they abide by the measurements. The most common modern practice for determining proportion is a grid system or a series of imaginary guidelines that determine the underlying format for a construction. This system is flexible and versatile and allows for consistency and clarity if used properly.

Typography

Typography is the art of the font. It is useful for both aesthetic appeal and functionality. Styles can vary in readability, and some are expressive and can convey ideas or emotion.

The primary distinction made between fonts is whether it has serifs. Serifs are the small strokes that form at the ends of characters in certain fonts. This is one of the most obvious ways to

classify a font, as each group is used in particular instances. Fonts that are serif contain these lines, and those without are referred to as sans-serif.

Readability of a font can vary. On screen, it is best to use sans-serif fonts, as the pixilation on serifs can hinder readability. It is also best for far-away text such as road signs. Among the best fonts for this are Arial, Helvetica, and Verdana. On paper such as printed in a book or letter serif fonts are generally better. Fonts like Georgia, Times New Roman, and Garamond are designed for artistic appeal and readability.

Since many icons are presented internationally and may be viewed by people of all languages and cultural backgrounds, text is rarely used. Fonts used to describe an icon are usually superfluous detail or added to compensate for a poorly-constructed visual. For most icons, text should be avoided. However, it is sometimes necessary to include text with the appropriate font in order to convey a particular meaning.

Perception and Illusions

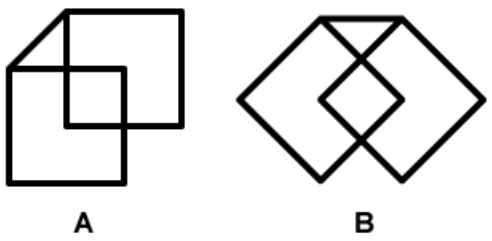


Figure 3 – Perspectives

Perspective changes one's perception of an image (Deręgowski, 1984, p. 22).

Human cognition can sometimes bend reality. Visual elements are capable of appearing different from how they are in nature. Perception and illusions can play mind tricks, which can be beneficial for icon development but also detrimental. Since the brain can naturally interpret images, icons could employ these illusionary practices in order to create a more effective visual. However, a designer could unintentionally confuse a viewer by neglecting to consider alternative perceptions.

The two similar shapes depicted in Figure 3 demonstrate orientation's role in graphic design. Image B is seen as a stable image, as it is balanced and symmetrical. Image A has depth but is instable. Perspective changes one's perception of an image (Deręgowski, 1984, p. 22).

Many people have seen the optical illusion that depicts two men in a room of one-point perspective. The illusion shows a picture of the same man in two different locations on the image.

The viewer usually identifies the man closest to the focal point as being larger than the other. However, the two figures are of equal size and proportion. The one man appears larger because of a practiced sense of perspective. Designers must account for such factors when designing icons. Though the icon may, in fact, look as it should, others might interpret it in a different manner. Since icons are designed for the viewers, it should be their observations that override the logic behind the image. The two men in this image look of different sizes though they are perfectly congruent.

It is essential to consider the effects of illusion in graphic images since it can alter perception. This phenomenon should be considered when designing icons. It can assist in representation by adding perceptional meaning, as well as an objective understanding, but can also be detrimental if the two interpretations conflict. Take, for example, the image with the two men of the same size positioned in different areas of a perspective room. They are mathematically similar but perceptually, one is larger than the other. These conflicting observations could create problems with interpretability. If the designer expects the viewer to see an object as is without considering perception, the viewer's understanding of the symbol may become skewed in an unexpected way.

Figure 4 – Explosion Warning Symbol

This symbol warns viewers that something has the potential to explode (Brimar Industries, 2010).

Another instance of optical illusions creating a false perception is with the common "two-pronged trident" (Deręgowski, 1984, p. 22). Though the figure is composed of a possible arrangement of lines and figures, the viewer attempts to perceive an eidolon. Viewing it as a representation of a 3D image from left to right or right to left will result in confusion. As a two-dimensional Cartesian figure, it makes perfect sense. This persevering ability to make sense from abstract symbols is what gives icons the ability to communicate information. All viewers will attempt to make sense out of the abstract, so creating an icon that is uninterpretable is the designer's fallacy.

If an image is placed on a canvas, the right side usually has dominance. In an image where the same object shows on the right and the left, the right one will appear larger (Martinez & Block, 1988, pp. 50-51). This may be the result of the majority of the population being right-eye dominant. People typically view an image from left to right and top to bottom, probably because most of the world requires this pattern in reading. It is typically easier to view and understand an image if the majority of the weight is on the left. The viewer sees the details upon first gaze, then transitions to the rest of the image without much obstruction. If an image tells a story, it will usually transition from right to left. The explosion symbol follows this principle. The original object is seen at the left but transitions into an explosion when the viewer looks right (see Figure 4). Similarly, there are observed perceptions about the top and bottom of an image. Because of gravity and a common arrangement of objects in nature, images seem more proper when there is more on the bottom (Martinez & Block, 1988, pp. 48-49). A typical cityscape may have numerous buildings, people, trees, and other details at the bottom and a clear sky with a few clouds at the top for detail. Viewers expect more weight and detail at the bottom. Typographers build letters so that they do not look top-heavy. Even letters that appear proportional and symmetrical, such as E and X, may be designed so that there is a big base at the bottom. Looking at a letter upside down will make the letter look awkward.

Cause is typically an important factor in sequences (Massironi, 1937/2002, pp. 205-208). The change among visual objects is clear in the sequences, but usually a reason is implied to commence such a change. A square may erode into nothingness, or a ball may roll over to an upright rectangle, causing it to fall. Some illustrations use sequences to show cause and effect, but it is not always necessary to use movement.

A visual object is a representation of something at a particular time (Massironi, 1937/2002, pp. 208-211). Leyton's theory states that graphic images can reveal hints about an object's history. For example, a picture of a vase with a chip or square with an unsmooth edge indicates the properties the depicted object once had. The theory states that shape gives an indication of time. Typically, this only works for shapes that are subject to memory recall such as common objects, regular shapes, and symmetrical figures. According to the theory, "asymmetry is the memory that process leave on objects." Usually, history adds wear and tear to shapes and objects, making them more asymmetrical. If an object is asymmetrical, it is seen as having a long history, as it was supposedly once regular. This is known as the Asymmetry Principle. The Symmetrical Principle states that symmetrical shapes are seen as having always existed as such and never experienced change. Basically, Leyton's theory states that objects can go from having symmetry to asymmetry, but not the other way around.

Concavity can affect the figure-ground interpretation of an image (Massironi, 1937/2002, pp. 223-235). Graphics that are convex, those that have protruding parts, appear to be the shape. Forms that are concave, those with elements appear inward, usually act as the background. Figure 5 shows two objects on a rectangle. Image A is convex and appears to be a shape in front of the rectangle. Image B is concave and has the appearance that the rectangle has a hole cut in it. The rectangle appears to be the figure in front. Most figures in nature appear as convex. Usually, if a shape is concave, it is the result of convex shapes surrounding it. For example, the particles that make up clouds in the sky are able to flow freely. Because of this, they typically shape themselves convexly.

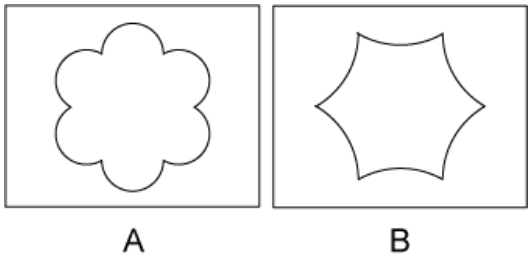


Figure 5 – Convex and Concave

Convex shapes appear to be the figure whereas concave shapes are seen as ground.

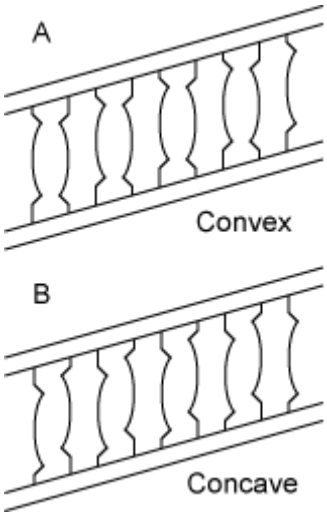


Figure 6 – Banister

This image of a banister illustrates how parallelism can make shapes appear as figures despite concavity. (Massironi, 1937/2002, pp. 223-235)

Familiar objects are more instantly recognizable (Massironi, 1937/2002, pp. 223-235). For example, if one looks at a drawing of a building and sees a rectangular shape on it that touches the bottom of the building's shape, most likely the viewer will assume it is a door. If the rectangle was above the bottom, it would look like a window. Basically, the viewer makes this association based on learned experience with similar objects. If the rectangles were fixated on a different object, such as a drawing of a computer, it would appear as though they represent the screen, buttons, or other peripheral device. If a viewer assumes correctly that the rectangles on a building represent windows and doors, then the viewer will be able to create a better mental model of the image. It will be clear which objects overlay which and what parts of the image are figure and ground. This asserts the gestalt ambiguities that are often present in abstract or simplified images.

If a shape has parallel sides, it is usually seen as the figure (Massironi, 1937/2002, pp. 223-235). Observe Figure 6. In

Image A, the banister spindles have a convex shape and appear to be the figure. The ground shape formed by the contours of the neighboring spindles appears to be as such because it is concave. However, in Image B, the roles reverse. The concave shape has parallelism with respect to the vertical, which makes it appear as the figure. The inside ground shape is still convex but no longer parallel.

The phenomenon of cognitive drag refers to the ability of the observer to perceive sequential images as one series, where each image in the sequence is a succession of the former (Massironi, 1937/2002, pp. 223-235). Typically, this strategy is used in comic books, where many frames compose a story that the viewer follows in a particular order. Adjacent frames gradually guide the viewer through the series. The sequence could be seen as an animation, such that a shape could gradually get larger, move, or change its form. The key to cognitive drag is subtle changes in each image. The graduation must be fine so that the adjacent images appear related. The drag occurs because the brain remembers the initial perception of the image and, therefore, can relate that to the new image, noticing the difference between them.

Spatial cues are necessary to show the relationships between objects in an image (Massironi, 1937/2002, pp. 223-235). The Gelb effect was coined after a perception experiment that involved suspending a black disk in an empty area of a dimly lit room. A projector shined bright white light on the black disk so that light would not shine on any other area of the room. Normal perception would determine that this is the color white. However, if one took a white object and placed it in front of the black disk so that the light would shine on it, the color would appear to be the white and dominate the previously perceived white of the disk. This experiment demonstrated that black and white were a perception and that the classification of an object as either black or white depended on the colors of the environment. Other experiments can support perceptive differences as well. Figure 7 demonstrates each example. If there are two concentric squares, one inside the other, it may appear as a square with a hole, as in Image A. It may also look like a square on top of another, or perhaps a square with a hole, and inside the hole is a square cut to fill that hole

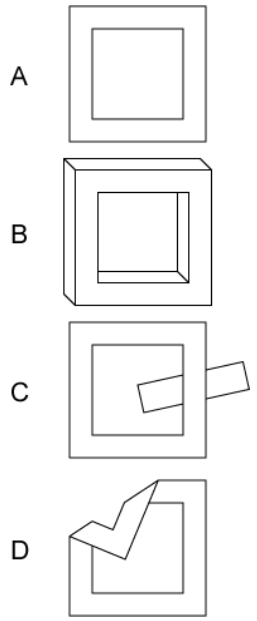


Figure 7 – Square with Concentric Hole

Illustrating different means to show that image A is a concentric square hole inside a square.

exactly. It may have several interpretations, but other perceptive cues can help illustrate the intended interpretation. For the sake of simplicity, the proper interpretation is a square with a hole inside it. Putting a three-dimensional effect on the square could show depth and clarify the matter, as in Image B. Placing an object behind the square frame so that it shows that the middle is removed is another method, as in Image C. Lastly, the artist could modify the shape to show it from a different perspective such as illustrating it so that it appears folded, as in Image D. This should help show that the middle is, in fact, a hole.

Consider the same shape used in Figure 8. If this shape changed to include a small rectangular piece that ended at the figure square, as illustrated in Figure 8, what would it appear to represent? Though there are many possible interpretations for this shape, most would describe it as a small rectangle that is partly hidden behind a square with a concentric square hole. This may be due to an economy principle that governs many perceptive cues in cognitive psychology (Massironi, 1937/2002, pp. 223-235). This is the simplest solution, so it is probably the correct one. Some may also make the argument that it could appear as many other situations such as a small trapezoid in the foreground that just happens to have a leg that falls flush to the square's edge. Based on the economy principle, one would make such an initial assumption because it simplifies the image, requiring the fewest layers (a foreground and background), and seems to unify the image, as one shape is behind another. Another factor to consider is what psychologists refer to as the Principle of Stimulus Determination. This states that the first perception a viewer makes is usually the one that makes the most sense.

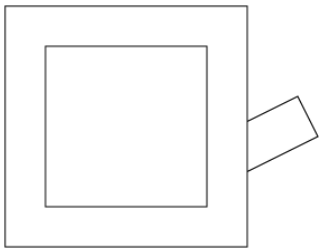


Figure 8 – Square Hole

A viewer assumes that the rectangle is hidden behind the square shape, indicating that the inside square is not a hole, and the rectangle is situated behind both squares. However, this image can be interpreted in a multitude of ways.

When designing images, it is essential to investigate any accidental coincidences that the image may represent (Massironi, 1937/2002, pp. 223-235). Subtle changes to an image can result in completely changing the perceived interpretation. For example, if an image of a square had two lines crossing as if to dissect the square into four smaller congruent squares, the viewer may see the image as four squares instead of crossed lines on top of a square. The Coincidence-Explanation Principle states that human cognition seeks the most obvious solution and typically does not consider an approach that is heavily based on coincidence. Take, for example, Figure 8. The figure could either be a square with a hole into which another rectangle fits perfectly or a

rectangle could overlay a perfect square. The simplest explanation is the latter; one shape overlays the other. The principle states that it is rare to see shapes that fit perfectly into each other in nature. Perception relies on the viewer's experience, so one is likely to assume the most commonly seen relationship. Since object occlusion is seen much more often, it is very likely that the viewer will assume this to be the case for this figure.

The principle of complete articulation is the psychological concept that states that the perceiver tries to organize elements as a whole so there are no leftover parts. If, for example, two parallel boards were situated slightly away from each other, but appeared to fit together perfectly as illustrated in Figure 9, the observer would see these as the same image, mentally connecting them.

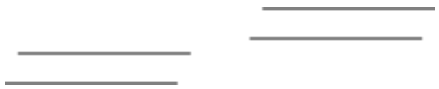


Figure 9 – Complete Articulation

The principle of complete articulation suggests that these parallel shapes can connect, so a viewer may see this as one shape divided.

A commonly referenced psychological experiment in perception and cognitive performance is Ridley Stroop's 1929 experiment involving reaction time and measurement of perception (Stroop, 1935). The experiment investigates what occurs to a reader first – a word's color or meaning. The experiment's setup is an arrangement of colored words usually on a black background. At the beginning, the subject would see words written in the color they spelled. For example, "red" would be in red, "green" in green, and "blue" in blue. In later experiments, the colors and words do not match. The word "green" may show in the color blue, and "purple" may show as yellow. Readers are instructed to read the word that is presented but sometimes mislabel the word, saying the color of the word instead of what the word reads. This shows that color is noticed before the meaning of a word, which makes sense since color is the first property the viewer will notice. Hence, it takes time and cognitive energy to resolve the conflicting stimuli.

Color is important for discriminating objects. However, artists are able to use colors interchangeably while still creating recognizable images. The brightness, or value, of a hue is most important in representing the depth of a form. Art by Matisse follows this rule. Paintings such as La Femme au Chapeau, that use varying hues with the proper values, is still clear despite the unusual colors (Conway, 2002, pp. 1-2). This is partly why objects in grayscale images are recognizable.

Representing the Invisible

In art and icons, there is often a need to show what cannot be seen. Most visuals depict tangible properties, but art is capable of expressing much more. How would one communicate smells, tastes, motion, shapes, physics, movement, emotion, or thought? How can a visual piece represent the unseen? Research offers insight to the many attempts at this throughout history. In icon development, it is sometimes necessary to apply these strategies in order to create a more effective symbol.

Figure 10 – Representing Sound in Icons

There are strategies for showing sound visually. In this common depiction, the artist uses different-sized lines and a prohibition symbol to show the amount of sound being produced.

Imagine an icon representing sound. This may be found on a computer, stereo, amplifier, or software application. Typically, it would illustrate a speaker facing rightward. To represent whether it was producing sound, and how much of it, is usually shown through straight lines or concentric waves originating from the speaker's open end; if off, the lines are not present. Sometimes this is shown by a prohibition symbol. As noted previously, visuals are often perceived from left to right. Therefore, the viewer would see the speaker before the waves, clarifying the lines' intended meaning. Figure 10 illustrates this example.

The artist needs to convey the representation in an easy-to-understand manner so that it is sensible to the viewer. Lines emanating from a speaker are obvious to most as indicating sound. However, sometimes the lines are not so obvious. If an artist were to place vertical wavy lines above a picture of a fried egg, the viewer may not know what it represents. It may depict steam, smoke, heat, smell, or maybe even sound. Selecting the proper lines is important. Sometimes the lines are self-explanatory depending on the object. Placing these lines above a fish would most likely represent smell and above a stovetop would represent heat. Usually the shape of the lines characterizes the message. Sharp jagged lines could represent pain, solid, straight lines could show sound, and soft, wavy lines may indicate smell. These patterns are characteristic of what they represent.

Representing the invisible is particularly important in mathematical and scientific drawings (Massironi, 1937/2002, pp. 141-177). Mathematical lines such as trajectories, measurements,

paths of motion, and microscopic details must somehow show. Architects use dotted lines to show the contours of objects positioned behind other figures. In reality, the opacity of the object in front would cover the object that is behind, but it is necessary to show all objects in blueprints. Measurements may also be necessary to note in these informative prints. Sometimes a simple line indicating the distance between two points suffices. More complicated, the construction of a geometric shape may be shown by revealing the invisible circular constructions necessary to properly draw the shape. Doors are drawn to show the swing direction. This both indicates which way the door will open and also shows which areas should be left unobstructed. Vector fields can illustrate the magnitude and direction of magnetic forces, wind, electricity, or fluid dynamic. A pattern of arrows reveal the information in a readable graphic manner.

Taxonomic drawings are a common method for showing the inner parts of organisms which, under usual circumstances, are not visible (Massironi, 1937/2002, pp. 141-177). Illustrations of humans and other creatures can show small details that are otherwise invisible to the naked eye. They also reveal the insides of the organism, many parts of which are not typically visible. Some illustrations reveal details about parts which are seldom seen such as the open wingspan of a flying creature or the profile of a plant showing all the roots that are hidden underground.

Comics and cartoons often employ these strategies to represent non-visual information in a seeable way (Cite McCloud). Speech and thought bubbles are used to show what a character communicates. This is accomplished by placing either a picture or text in the bubble. Lines are an important tool in cartooning, as they can demonstrate movement, direction of gaze, aim, and other important details. Lines around a hand show that a character is waving. Well-known cartoonist, Scott McCloud, details many of these concepts in his casual, yet informative books and website.

Some of the above-mentioned examples are allegorically visible representations, and others are concretely invisible.

Color Psychology

Color has a profound impact on an icon’s meaning. Many researchers have executed numerous experiments on color psychology in an attempt to develop an understanding of the phenomena of human perception. Results show that all people generally react similarly to colors, but culture is among one of the most significant variables. This experiment will test the effects of color on one’s interpretation of an icon.

Multiple studies have shown that colors evoke emotion. For the sake of relevance, this paper will only investigate the five that are used for this experiment: blue, red, green, orange, and black. When one characterizes a color, it can be labeled with subjective physical properties such as weight and temperature (Sharpe, 1975/1981, p. 8). It may seem like it is open to individual interpretation such as a poem but, strangely, many agree about the properties certain colors exhibit. Artists use both objective and subjective descriptions to label colors. Descriptors such as a tint, shade, and hue all relate to the quality of the color, but labeling a color as warm or soft refers to its interpretation.

Color Therapy and Human Response

For many years, chromotherapy, the practice of healing with light, was robust and respected. One of the most influential color therapists was Edwin D. Babbitt, who documented his theories for healing with the power of colored light. His work was often refuted by medical professionals, though some believed his skills were apt. Sidney L. Pressley was among the many who denied Babbitt's credibility, stating that if color does have an impact on one's physiology and mentality, it is subtle and unspecific. The practice entailed aiming specific wavelengths of light in particular places depending on the ailment (Birren, 1978, pp. 52-65). Some chromotherapists gave light energy prescriptions for numerous treatments. For example, the treatment of epilepsy involved shining blue light, the calming color, over the patient's head, spine, and solar plexus. Therapists stimulated dormant kidneys using red or yellow. For tuberculosis, the cure was yellow and in some instances ruby, over the chest. The claim was that violet light destroys the bacillus in tuberculosis. Gastritis, nausea, and indigestion could be fixed with light depending on the condition. A soothing blue could cure inflammation, and green could calm the organs. It was also noted that ruby, a stimulating color, was beneficial for the stomach. Many were skeptical that these methods would cure what the chromotherapists claimed.

Chromotherapy has since lost its credence, but color psychologists have shown that certain wavelengths are able to evoke mental and physiological responses in humans. This has been measured using several testing methods, some conventional, others using avant-garde technology (Birren, 1978, pp. 13-25). The use of galvanized skin response technology to measure palmar conductance, electroencephalographs to monitor cortical activity, and polygraph tests, that measure many facets of physiological reactions to stimuli, all show that viewing colors causes reactions. An essential consideration for which many color experiments fail to account is that the psychological and physiological effects of color are temporary. Similar to the effects of alcohol or coffee, the body eventually returns to its normal state. The color red stimulates, but

after constant exposure the body's responses drop below normal, contrary to its initial effects. The effects of color are dependent on their relation to time.

Color Meanings and Representations

Cultures tend to have certain sets of beliefs about what they feel certain colors represent. The meaning of colors can vary across nations. Many countries herald certain colors on their national flags based on these beliefs. The purposes of each color in all cultures are far too numerous to note in even a condensed manner.

Everyone has ideas of what a color represents. Usually, the meaning of colors is unconscious, and sometimes it is a shared belief. Colors have the capabilities of invoking psychological responses such as emotion. Depending on a person's background, culture, and knowledge, colors will have particular associations. Since this thesis involves black, white, blue, red, orange, and green, these colors will be discussed.

In modern America, the consensus is that red represents heat, fire, and blood (Birren, 1992, pp. 142-144). Red generally appears brilliant, intense, opaque, and dry. It has the impression of danger, passion, excitement, fervor, and activity. Subjectively, it can be seen as intense, raging, rapacious, and fierce. Red is dynamic and dominant (Birren, 1992, pp. 257-261). It causes excitement in living things, stimulating the growth of plants, accelerating development of simple animals, and increasing hormonal and sexual activity, and it has the ability to heal sunburn, inflammation, rheumatism, and other ailments. Research shows that it is also capable of changing pulse rate and blood pressure. Red creates excitement, increasing restlessness and nervous tension. Normally red light creates an ideal environment for incubating ideas and brainstorming, but will not improve one's ability to follow through with the idea. Red typically causes one to overestimate time and makes objects seem heavier. Pure red is too vibrant and usually causes afterimage when seen under normal conditions. A rich red captures attention. Variations of red are universally pleasing, especially by extroverts. The effects of red have been used to treat depressive moods and turn one's interpersonal attention to the surroundings. It has been documented that thieves target red cars more than any other color, and red cars are also more likely to be pulled over by police for speeding, as red is a high energy hue (Rousseau, 2008, pp. 14-16).

Orange stands for warmth, metal, and autumn (Birren, 1992, pp. 142-144). The color is bright, luminous, and glowing. It is seen as being jovial, energetic, lively, and forceful, and can be interpreted to represent hilarity, exuberance, and satiety. It is also a very alarming and attention-

grabbing color used to create awareness. It is used on some warning signs, as it draws attention. Certain game hunters wear orange to stand out amongst the natural green and brown foliage so other hunters can see them. Orange has similar effects as red (Birren, 1992, pp. 257-261). Though many are not aesthetically fond of pure orange, variations of the color are very well received. Tints and shades of orange such as salmon, peach, and brown, are commonly used for building interiors. They are pleasant and calming, mellow, and more modern than red. On human skin, it has a cheerful and flattering appeal. The subtlety of the color makes it desirable in large quantities, exhibiting a livable charm.

Green is cool and natural and represents water (Birren, 1992, pp. 142-144). The clear, moist color is quieting, refreshing, peaceful, and nascent. Contrarily, it can have a subjective meaning of ghastliness, disease, terror, and guilt. Shades of green have varying effects (Birren, 1992, pp. 257-261). Yellow-green is typically considered a neutral color and has few psychological effects. Greens and blue-greens are relaxing, pacific, and reduce nervousness and muscular tension. This color is used to increase concentration and may create an ideal environment for sedentary tasks and meditation. Like peach colors, bluish-greens also lack primitive appeal and create an ideal color for a livable environment. Both colors complement each other. Blue-green is also the color of the average human complexion and is appealing to most as a background color. These colors, as well as tints of orange, work well together aesthetically. Green, because of its majestic soothing effects, is usually adopted to help people relax. Before appearing on television, many prepare in a green room (Rousseau, 2008, pp. 14-16). Many hospitals elect green as a common room color because it calms patients.

Similar to green, blue represents cold, sky, water, and ice (Birren, 1992, pp. 142-144). The transparent and wet color can also symbolize service. It is subduing, melancholic, contemplative, and sober but can also represent gloom, fearfulness, and furtiveness. Psychologically, blue opposes red (Birren, 1992, pp. 257-261). Blue has the complements for almost of all of red's attributes. Blue seems to stunt plant growth as well as hinder hormonal and sexual activity and wound healing. Blue too can change the pulse rate and blood pressure in humans, but, antithetical to red, it lowers both. Time is typically underestimated and objects in blue light appear to have less weight. Blue is flexible enough to create desirable tones using tints and shades at varying levels of saturation. Though it is a preferred color for many and may be suitable for the interior design of homes, it is usually not successful in business settings such as offices, schools, and hospitals. Typically, blues are best left to small areas and not appointed as the dominant color in a setting. Pale blue is calming, but many report that it bothers the eyes. It also makes adjacent objects appear blurry. Blue is a very passive color and does not grab attention. Despite its shortcomings, many people worldwide adopt the color for its restful and easygoing appeal.

Black, perhaps the most powerful of all, represents special darkness and emptiness (Birren, 1992, pp. 142-144). It is a neutral color that is often associated with night, mourning, death, depression, ominousness, and godlessness. Contrarily, black can also show submission to god, as priests wear black robes (Rousseau, 2008, pp. 14-16). It is a color of authority. White is spatial, light, cool, and clean. It is the color of purity, youthfulness, normality, and brightness of spirit. White, black, and gray are neutral colors (Birren, 1992, pp. 257-261). White is considered to be a perfectly balanced color, as it is clear, natural, and a combination of all visible colors. It also symbolizes cleanliness and sterility, which is often why nurses and doctors wear it (Rousseau, 2008, pp. 14-16).

White, gray, and black are positive, passive, and negative respectively. All do not evoke emotion and lack psychotherapeutic capabilities, making white the ideal background and black the ideal figure control for this thesis.

Color in Icons

Color psychology is a factor in many disciplines. The fields of fine art and design are clear, but usually the person selecting color chooses the palette based on aesthetic preference not psychological reasoning. Signage companies, advertising agencies, and safety committees may consider cognitive psychology when making informed decisions. Since this study involves icons and symbols, studying the development of street signs may offer insight.

The modern American traffic light typically contains three horizontally aligned colored circles of red, yellow, and green (Castro & Horberry, 2004, pp. 77-78). The lit color instructs the driver to follow a certain set of rules. Though the details of the rules are taught in a driving class, the understanding of each color matches the respective instruction. Color is typically a secondary design feature in traffic signs. They support the overall impression of the sign. Most signs incorporate a graphic symbol or words written in a readable font (usually Helvetica or a variation thereof) as the primary means of communication. The color of the sign assists the presentation of the message. An investigation of color psychology is necessary to select the wisest color for each sign type.

A sign's conspicuity is the degree to which a sign is noticeable (Castro & Horberry, 2004, p. 121). Numerous factors affect a sign's conspicuity, including sign size, angle of observation, color, brightness and contrast, and dynamics. Factors of the observer such as alertness and search patterns, will also affect conspicuity. This is particularly important in older drivers, as it takes more time for an older driver to notice and respond to a sign than someone younger. Making a sign

noticeable can make it stand out among clutter. Color is one of the major factors in signage and a significant part of attaining the proper conspicuity.

Sign color and shape are factors that convey the sign's meaning (Castro & Horberry, 2004, pp. 42-46). Sets of uncompromising standards are regulated in the United States based on psychological research. Most other countries have adapted the same or similar sign construction mechanisms. The specificity of color is described by its chromaticity based on the CIE Chromaticity Diagram. Color on signs is used sparingly, as it takes precedence over white and also loses luminance. White has a luminance of 1.00. Using this as a guide, yellow is 0.95, green is 0.7, red is 0.1, blue is 0.05, and violet 0.0005. On signs, some may report certain colors to be brighter than others due to the reflectivity.

Signs, whether for traffic or labels on a product, contain certain colors based on psychological concepts. On roads, the typical color for informational signs such as streets and towns is green. It's not alarming but does not recede into the background and become unnoticed. Usually the people reading street signs are looking for them. Drivers expect them to be a certain color so they are identifiable. Typically signs that are warnings or alerts are much more commanding of attention. They are typically a vibrant warm color, usually yellow, orange, or red, and stand out in almost any background. Imagine if a stop sign were green. Red symbolizes a warning, instructing the driver to stop. If the sign were green, a color calming and permissible, the driver may have conflicting opinions about the sign's command. This would exhibit a situation where conflicting cues may delay responses or cause the observer to conclude incorrectly.

Color Preferences

The typical American classification is that blue is a boy's color and pink is for girls. This is an example of a shared-color interpretation. For certain situations, one color can be favored over another. Though this may be fueled primarily by artistic preference and style choice, there are physiological and psychological reasons behind the favoring of certain colors.

Scientific investigations conclude that people may favor certain colors depending on the environment in which they are most familiar. Furthermore, these tests conclude that people fitting certain physical demographic profiles, such as eye, hair, and skin color, prefer certain hues (Birren, 1992, pp. 179-181). Personality profiles reflect a color preference as well, as introverts prefer blue and extroverts red. Brunettes and blondes prefer red and blue respectively. This is concluded to be the result of skylight and sunlight in certain regions of the world. Colder climates typically have higher skylight and less sunlight than warmer ones. Since people are constantly

exposed to certain environmental lighting conditions, the eyes adjust accordingly. In environments with intense light, the eyes may adapt and develop red-sightedness. The eye may also develop strong pigmentation in the foveal region. This typically happens with brunettes such as Latinos, as they typically reside in light-intensive areas. They usually favor warm hues, a result of psychological accommodation to long wavelength light rays. Blondes, typically from Norway and Scandinavia regions, are usually green-sighted and favor cool colors like blue and green. They may have different foveal pigments than their red-sided counterparts. Therefore, people who live in well lit areas tend to prefer warm, bright, saturated colors. Those from areas where light is less abundant prefer cooler and softer hues.

Older people favor blue (Birren, 1992, pp. 179-181). The theory is that when a person ages, the fluid in the eye yellows. The lens of a child's eye will absorb about 10 percent of blue light, whereas an older person would absorb about 85 percent.

Diet may also affect color preference (Birren, 1992, pp. 179-181). A study showed that Mexican children preferred colors of high discrimination such as blue, yellow, and red. When the diet was corrected to include more calcium, the children were able to appreciate more subtle differences between colors.

This can add another variable to the ability to interpret color in icons. Because perception of a color may vary across individuals, people may have varying opinions on what each color means. Though there are several demographic details that may add more insight to this study, the measurements will be kept at age, gender, country of origin, and technical experience, as these are some of the more relevant characteristics. Having too many questions in a pre-survey questionnaire will discourage users from taking the actual survey.

This experiment will test people's interpretation of black, red, blue, green, and orange icons. The shapes will remain the same, but each one will be presented in a random color. The viewer may interpret these colors differently. For example, a circle with a vertical line underneath could have a multitude of meanings. If the icon is black, one may think it's a person, as it could be seen as a highly stylized and abstract version of a human. If the icon is orange, it may look like a key, as many keys have a metallic color. If the same shape is presented in red, it may appear as a lollipop or piece of candy, as many candies come in this color. A blue image may look like a balloon, as the shape and color match its typical depiction. A green icon may look like a tree, as many organic objects are this color.

Eye Anatomy, Physiology, and Vision

Before researching and measuring interpretation of visual symbols, it is important to have a basic understanding of the eye's motor system and neural network.

Eyes are essential for the survival of most species. They have evolved into one of the most complex organs in the human body. Though vision is vital, the brain does not allocate much space to provide total accuracy in a wide vision field. Species are then given a balance between vision field and accuracy. A hawk has a restricted field of view, but very accurate eyesight. A rabbit, conversely, has poor vision accuracy, but a large vision field. Humans evolved an anisotropic retina with high spatial resolution in the center 0.1%, known as the fovea, surrounded by a region of lower resolution, known as the peripheral retina. This allows humans to see a wide range (almost 180 degrees) and focus on important details. Humans compensate for a small focal range by moving the eye rapidly, refocusing on many places to get the big picture. These are known as saccadic movements and are some of the fastest kinesthetics of the human body, capable of rotating over a 500-degree span per second. An average human will perform well over 100,000 of these movements daily (*Eye Movements*, 2004).

The eye works with seven muscle groups collectively known as the muscles of the orbit. Six control the eye, and one, the levator palpebrae superioris, the upper eyelid. The four rectus muscles (superior [elevates, adducts, and medially rotates], inferior [depresses, adducts, and rotates laterally], lateral [abducts], medial [adducts]) and two oblique muscles (superior oblique [depresses, abducts, and medially rotates], inferior oblique [elevates, abducts, and laterally rotates]) are the six muscles that rotate the eye ("The Eye and Orbit"). All eye muscles are much stronger than necessary, indicating that the muscles should be able to perform well under long durations such as the constant saccadic movements used to observe and study an image. This experiment will not account for variables for muscle fatigue of the participant over time.

Four other eye movements help sustain a clear image. The Vestibular-Ocular Reflex, or VOR, rotates the eyes to keep a focus on an object when the head and body are moved. This reflex is highly dependent on the semicircular canals and otolith organs in the ear to judge balance and movement. Optokinesis keeps focus on moving images by rotating the eye at the same rate that an object is moving. Following the object removes the blurred image motion. Smooth-Pursuit eye movements are similar but focus the eye on large moving targets with no defined focal point. The eye is incapable of moving smoothly across a stationary object but can if following a moving object. This is another important factor to this eye-tracking system, as the user is usually interacting with a stationary computer screen. Vergence movements keep the eyes focused on

objects that are moving closer to or further from the viewer by rotating the eyes inward or outward (*Eye Movements*, 2004).

Future eye studies, such as perimetry and depth of field studies, may also help us understand the eye's capabilities and limitations.

When one compares objects of different shades, the discrimination is relative to the surrounding details (Carraher & Thurston, 1966, p. 12). A gray object may be seen as black if on a white background, and white if on a black background. The color of the object remains the same, but the viewer's perception changes. A movie screen is white, but when a video is projected on the screen, the darkest elements on the film appear black, although they are merely unlit segments of the screen, much like the Gelb effect.

White shapes appear to occupy more space than dark (Carraher & Thurston, 1966, p. 12). The white color appears to spread over the retina, affecting receptors in a less accurate way. A white square on a dark background may appear larger than a congruent dark square on a light background. This occurrence is termed irradiation. Each color has different weight. Typically, darker colors have a greater weight than lighter (Martinez & Block, 1988, p. 212). Otl Aicher's logo for the International Olympic Committee contains five colors: black, light blue, yellow, green, and red. Each ring is a different color. Though the rings appear to be the same, each one has a particular thickness. The differentiating thicknesses are based on the weight of each color. If the light blue is 1 unit thick, red and green are also 1, the black is .92, and yellow is 1.3. Despite the variations in size, they all appear the same in print.

Optical Path

The optical path begins when light contacts the eye through the outer protective membrane, the cornea. The light then passes through a jelly-like substance filling the anterior chamber called the aqueous humor that provides nourishment to the lens and cornea (Lindsay & Norman, 1977, pp. 56-82). Next, the light encounters the gateway to the eye, the pupil, which is responsible for controlling how much light enters. The pupil contracts in brightly lit areas and expands to allow more light to enter in dimmer environments. The pupil can range from 2mm to 8mm in diameter. At its narrowest, it can let in about 1/16 of the light that would enter at its widest. When constricted, the intensity of allowable light reduces by about 12 decibels. Dilation is typically slow, taking as long as 5 minutes to open from a very closed to an open position. Studies suggest there is a link between pupil size and emotional involvement in a task. Though pupil size is typically for

controlling the amount of light that enters the eye, large pupils indicate a high emotional investment in the solving of a complex problem.

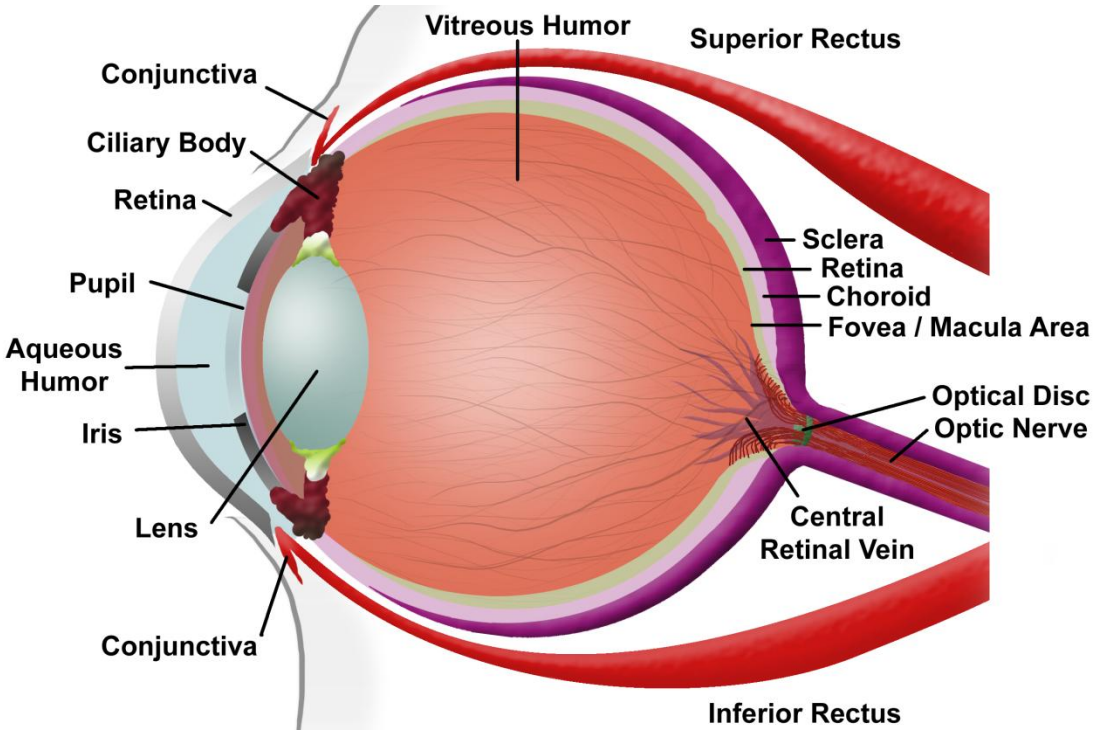


Figure 11 – The Human Eye

This simplified profile of a human eye shows the major parts of the organ.

When light waves reach the transparent lens, they are bent and refocused to eventually hit the receptors (Lindsay & Norman, 1977, pp. 56-82). The lens contains many thin layers of a crystalline tissue and is capable of expanding and contracting to adjust the concavity of the lens. Focusing on a near object will typically require a thicker lens than would something distant. A relaxed eye is usually in the position to study a distant object. The lens is elongated. To turn the eyes inward requires muscle pull. Typically those who have difficulty thickening the lens require reading glasses. This usually happens with age. Because the light arriving at the edges of the lens converges differently from that entering through the center, there is a distortion referred to as spherical aberration. More important to this study is chromatic aberration, the distortion caused by the refractive variation of different colored lights. Since the lens is composed of living cells and requires nutrients, it gathers them from the surrounding liquid. The cells in the lens' center are

less likely to receive adequate nutrition and may die before the others. Vision can fail as the organism ages. A dying lens can cause focusing problems.

After passing through the eye's jelly-like vitreous humor, the light reaches the retina (Lindsay & Norman, 1977, pp. 56-82). This surface covers the back of the inner eye and contains the visual receptors. These nodes contain nerves which are tangled inside the eye and attached to the optic nerve. The placement of the optic nerve in the rear of the inner eye creates an absence of visual sensors in that region. This creates a blind spot.

The retina contains multiple sensors called rods and cones (Lindsay & Norman, 1977, pp. 56-82). Rods are responsible for color vision and cones identify light intensities. The rods contain rhodopsin, a purple photochemical believed to be responsible for color vision. Cones contain various chemicals responsible for color vision and are about 500 times more sensitive to light than rods. One eye contains about 6 million cones and 120 million rods. These sensors are dispersed about the retina but are most concentrated around the center of the eye. The peripheral regions have fewer receptors. Contrary to the density of sensor population, more rods are found in the periphery than the center. Cone populations are dense in the center. This dense region in the center of the eye, the fovea, contains about 150,000 cones per millimeter. This region has the most acuity. Sensors in the foveal region also have a private connection to the brain. Between the two eyes, a total of approximately 250 million receptors send information to the brain using around 1.6 million nerves fibers.

There are three types of cones, each with certain pigments responsible for interpreting a range of colors (Lindsay & Norman, 1977, p. 113). One is most capable of identifying light between 445 to 450 nm, another between 525 and 535 nm, and the third ranges from 555 to 570 nm. Together they allow the viewer to understand the entire visible spectrum. The normal eye is capable of discriminating 180 different colors that will not look like others if the intensities vary (Birren, 1992, pp. 181-183).

Perceptual effects can alter one's vision. The eye's physiology may distort an image as it does in the negative awareness phenomenon (Carraher & Thurston, 1966, p. 12). When one stares at an object for a long duration, the rods and cones are constantly receiving the same signals. When they eventually become tired and overused, the observer may see the negative of the color where the object once was. If one stares at a white grid on a black background or black grid on a white background, the viewer may begin to see a dot in the intersection that matches the background. Staring at a particular color can cause the inverse color to appear when the viewer looks away.

The optic nerve is responsible for carrying the signals from the receptors to the brain. Several interconnected neurons, cells which pass electrochemical brain impulses to each other through axons and dendrites, form the nervous system. The cells exchange small electrochemical signals, sending the current throughout the organism. This enables moving, thinking, and feeling. Neurons can be up to three meters long, and the currents can travel anywhere from 10 to 120 meters per second (Fischler & Firschein, 1987, pp. 58-60). Nerves travel throughout the human body. Some nerves end at the skin's surface, enabling feeling through touch.

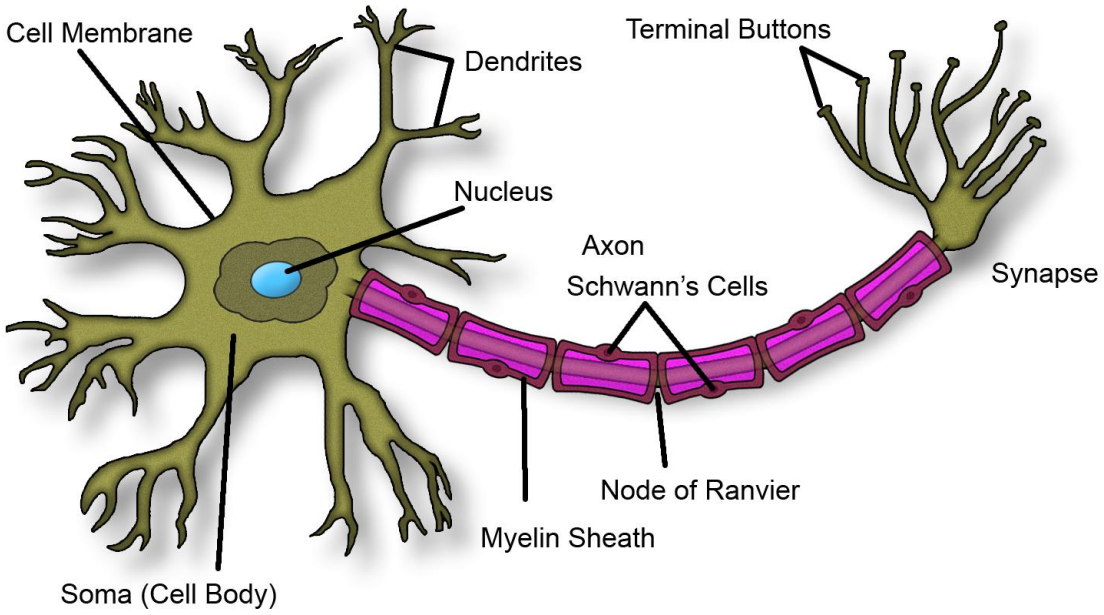


Figure 12 – Multipolar (Motorneuron) Cell

The diagram of a multipolar neuron illustrates the major parts of the cell.

A neuron is composed of several parts. When a current travels, it enters the neuron through the dendrites, tiny fibers that extend from the cell body, also known as the soma. The signal travels down the axon, a long cable-like appendage that carries the electrochemical current along the length of the cell to connecting cells.

A neural network is a system of neurons that connect and exchange impulses. Each neuron can directly connect to up to 200,000 other nerve cells, but most neurons connect to between 1,000 and 10,000 (Fischler & Firschein, 1987, pp. 58-60). Cells connect between the terminal buttons of an axon and an adjacent cell. This connection passes the electrical current from one cell to another. The cells do not touch at this point. There is a microscopic gap between the two called

the synapse. There are three types of synapses: axodendritic (axons pass a signal to dendrites), axosomatic (axons pass a signal to the soma), and axoaxonic (axons pass a signal to other axons). The nerves pass signals over the synapse. If the signal is strong enough, it will pass onto the next neuron and can cause a chemical or electrical change in the network. If it is not strong enough, it will fail, and the signal will die. The signal strength required to jump the synapse is called a threshold.

Most neurons contain myelin, a fatty tissue which cushions the axon and protects the cell and signal (Fischler & Firschein, 1987, pp. 58-60). Neurons that do not have myelin are usually found in the brain and spinal cord, while myelinated neurons are found in motor and sensory nerves. It helps keep the impulse from spreading. Regardless, some current escapes through the myelin.

There are four main types of neurons (Fischler & Firschein, 1987, pp. 58-60). Motor neurons carry signals from the central nervous system to outer body parts such as skin, muscles, and glands. Sensory neurons carry signals from peripheral body parts to the central nervous system. Receptors absorb stimuli from the environment and encode them into electrochemical messages that the brain can understand. Sensory neurons carry these signals to the proper organ. Interneurons are bridges that connect various neurons in the brain and spinal cord.

Simple creatures do not have brains (Fischler & Firschein, 1987, pp. 58-60). Instead, they function through a system of neural nets and reflexes. Flatworms, as well as all other invertebrates, operate through neural nets. Simple vertebrates such as lobsters have a collection of neurons called ganglia. A ganglion is capable of controlling motor and sensory functions through reflexes. As creatures get more complicated, the ganglia become centralized simple brains.

A variety of cells carry the signal from the eye to the brain. The receptor sends the signal through a synapse to a bipolar neuron, which then sends that signal through a synapse to a ganglion cell (Lindsay & Norman, 1977, pp. 56-82). The axons of this cell make up the optic nerve. At each synapse, horizontal neurons interpret the signals. They are responsible for the neurological processing within the retina. In the foveal region, one receptor may send a signal to one bipolar cell that sends it to one ganglion. As previous noted, foveal receptors have a direct connection to the optic nerve. Peripheral ganglia may receive signals from many receptors. This interplay of impulse exchange between the retinal cells produces a sharper, brighter, more colorful interpretation of an image.

The optic nerve is a collection of about 800,000 ganglion fibers originating at the retina (Lindsay & Norman, 1977, pp. 56-82). This cable is about half a centimeter in diameter. The right and left optic nerves cross to connect to the opposite sides of the brain. The intersection where the optic nerves cross is the chiasma. All imagery left of each fovea is sent to the right half of the brain, and any right image is sent to the left.

Saccadic movements allow the small foveal region to explore a broader range (Lindsay & Norman, 1977, pp. 56-82). The movements typically happen four or five times a second in humans. The movement is a powerful, abrupt force to the six extraocular muscles to change the orientation of the eye. The movements are ballistic, as they require no correction after completion. Unlike the moving of a hand to grab an object where the hand reorients itself during the movement, the eye simply goes to a position without further consideration or correction. The movement has been compared to throwing a ball, where after the object leaves the hand, the thrower no longer has control over it until it stops.

Though the ability to recognize patterns and objects is not yet well understood, scientists believe the brain is designed to interpret what and where something resides in the visual field (Lindsay & Norman, 1977, pp. 56-82). Identifying and locating an object in the visual field are independent of each other. When identifying something in view, the characteristics are noticed and analyzed. The brain sorts the perceived information. Orientation, distance, and location are not important. Position and orientation are only relevant to locating an object. When locating, identification is not essential. Evidence suggests that the ability to identify and locate may have separate neural pathways. Together, these systems allow the viewer to discriminate and analyze the visual environment.

Limits and Weaknesses of the Human Eye

When viewing objects in a space or recalling the positions of objects in a room, the brain uses a cognitive map to represent the objects in relationship to space (VanDoorn, VanDeGrind, & Koenderink, 1984, pp. 323-358). If someone asked for directions to a location, one would have to recall a map of the town, perhaps even cognitively orienting the map to label direction. If one was asked to describe a room, they would recall the space and objects in it, thinking about how best to describe the image. The difficulty is not in recall but in arranging and manipulating the mental model. The problem with using language to convey such a model is that many spatial relations are perceptual such as using left and right.

Typically when people communicate the position of two adjacent objects, one acts as the located object and the other as the referent (Van Doorn, Van De Grind, & Koenderink, 1984, pp. 323-358). One will either be left or right of the other. If two balls were adjacent and positioned in front of an observer, either sentence would work. However, if two objects with a definite front (making it possible to indicate which direction the object was facing), such as two people, were positioned in front of an observer facing the observer, the observer could report that one is to the person's right or left. If that observer were to change the perspective and view the objects from the opposite direction, the balls would appear the same as they did before and the references would not change. The people, however, would be seen from behind, and the viewer's left and right would match the people's, thereby limiting the descriptions of the position to one.

Language has two systems of referencing spatial relations (Van Doorn, Van De Grind, & Koenderink, 1984, pp. 323-358). The first is the deictic system that refers to positions based on the observer's perspective. When using the intrinsic system, the observer describes positions in relation to referent objects, particularly their orientations. This system requires a reporter to note objects in a scene and their orientations before being able to describe it. Intrinsic descriptions also require being able to distinguish the orientation of objects within a scene. This is usually deduced with objects familiar to the user where a loose functional relationship is recognized. Typically, an object's direction is classified because of the orientation they have when they are used. A desk, for instance, is used when facing the drawer side and, therefore, that will be the front. A chair's front is usually the side that does not have a back rest. The intrinsic system is based on the speaker's perspective, whereas the deictic system is based on knowledge.

The brain makes both deictic and intrinsic interpretations when distinguishing objects in relation to each other. Humans classify objects as having a front and back and usually decide which side is left and which is right. This is important to the interpretation of icons, because it demonstrates the mind's ability to make sense of objects at unusual orientations.

Some limitations are physiological. Glare and excessive brightness can cause discomfort and in extreme cases medical problems. People who live in snowy regions occasionally suffer from "snowblindness" as a result of the light reflecting off the white surfaces outdoors, causing long-term damage to one's vision. In small doses, the vision loss is temporary. White rooms are usually an adequate interior design strategy, although they are sometimes bland. Though many institutions adopt this color scheme, it is not recommended for well-lit environments such as hospitals and schools. Like the snow effect, the white walls reflect the atmospheric rays, making the room too bright. The high illumination levels can be hazardous, especially if white is used on

much of the area such as walls, ceilings, floors, furniture, and even clothes. Off-white, pale, or matte colors keep aesthetic subtlety without straining the eyes.

Color Wheel, Color Vision, and Colorimetry

Since this thesis involves visual interpretation and color psychology, an understanding of light physics and the visual system will help broaden the understanding of the topic.

Light travels in transversal waves and is usually described by the wavelength and intensity. The wavelength, or the length between two consecutive crests or troughs, defines the perceived color or hue and is usually measured in hertz. A hertz is the measure of one cycle per second. The intensity, or amplitude, describes the distance from the median to either the crest or trough and is typically measured in decibels. Intensity is usually described as measurement of brightness. Light waves can be virtually any intensity and wavelength (Lindsay & Norman, 1977, pp. 56-82). The visible spectrum is a subregion of the electromagnetic spectrum (Malacara, 2002, pp. 1-17). Though the spectrum is comprised of waves of varying wavelengths, humans are only able to see the range between 380 and 740 nm. The color blue has a wavelength of about 430 to 500 nm, green about 520 to 565 nm, orange about 580 to 625 nm, and red between 625 and 740 nm. White is a combination of all colors in the visible spectrum, and black is the absence of all color and light energy. Newton discovered this after separating white sunlight with a triangular prism, separating the beam into a spectrum comprised of red, orange, yellow, green, blue, indigo, and violet, respectively.

The color wheel is a circular chart that organizes all hues of visible light. The map shows the relationships between colors and assists designers in choosing appropriate color combinations. The wheel in its simplest form will consist of the primary colors (red, blue, and yellow) and secondary colors (green, violet, and orange). It can grow to include tertiary colors, quaternary, or a blend of all colors. Some contain tints and shades, which are variations in the lightness and darkness of a hue. Most computer applications use a color wheel as a means for selecting a color, including a side bar for adjusting saturation and varying the strength of a hue. This model is ideal for demonstrating color combinations and selections and is used by artists and designers as a reference.

Additive and Subtractive Colors

Mixing colors creates new hues. There are two schemes for mixing colors: additive and subtractive.

Usually, children are taught the subtractive color scheme first. This describes the mixing of colors whose frequencies are subtracted using red, yellow, and blue as the primary colors (magenta, yellow, and cyan is a more sophisticated color model used in printing). When blue paint is spread on a canvas, it appears blue because white light strikes it, and all colors but blue are absorbed. The blue is reflected to the observer's eye. If yellow paint is spread next to the blue, the yellow will reflect and the observer will see yellow. If the two paints mix, the colors reflected will be blue and yellow, which make green.

The subtractive color is dependent on which frequencies of light are absorbed, whereas additives are based on which frequencies are projected such as in mixing light. In the additive model, red, green, and blue are the primary colors. When lights merge, the frequencies are combined to create a color closer to white. For example, mixing red and green light makes yellow, as this falls between these frequencies on the visible spectrum. All primary colors together create white light, and the absence of light is black.

The Normal Trichromat

Human vision is capable of analyzing three color stimuli known as the trichromat (Jacobs, 1981, pp. 23-32). Thomas Young asserted that there are three types of nerve fibers in the eye, each responsible for a certain color stimulus. One nerve sees red, one green, and the other violet (Conway, 2002, pp. 3-6). With these three variables, humans are able to see the entire visible spectrum. Stimulating different combinations of nerves in the eye creates the perception of a wide range of colors.

Colorblindness and Other Notable Eye Maladies

Males are much more likely to be colorblind than females. About 8% of males have some form of colorblindness and only about 1% of females have this problem. Having color as a variable in this thesis may result in a slight favor toward the female population, as approximately 8% of the male participant data for colored icons should be neglected.

A way of determining if one is colorblind is by administering the Ishihara Test for Colorblindness. This test is a series of circles composed of colored dots printed on individual plates. It offers an accurate and quick measure of congenital color deficiency, the most common of color vision problems (Ishihara, 1970, pp. 1-6). Inside this assortment are a series of dots arranged in the shape of a number which are slightly different from the rest of the hues in the diagram. People with normal color vision should be able to identify the number represented in the circle.

The test checks for the intensity and type of red-green colorblindness. The protan type may be either complete (protanopia) or partial (protanomalia) (Ishihara, 1970, pp. 1-6). Protanopic people have a shorter visible range, and blue-green appears as gray, as does the reddish-purple range, blue-green's compliment. The deuteron type may also be complete (deuteranopia) or partial (deuteranomalia). In deuteranopia, green appears gray, as does green's compliment, reddish-purple. Each malady splits the visible spectrum with an area of desaturation. In protanomalia and deuteranomalia, the gray part of the spectrum appears as a grayish indistinct color. A notable phenomenon that occurs in red-green deficient people is an astonishing clarity for yellows and blues. Some cases show that congenital color deficiencies can weaken the ability to distinguish between all colors, making only vivid colors distinguishable. Some also have total colorblindness and lack the ability to identify any hue. Typically, this is the result of central vision impairments such as photophobia and nystagmus. Blue-yellow deficiencies are incredibly rare, and patients are seldom tested for this malady. Such impairment is titled tritanomalia if partial and tritanopia if complete.

The Ishihara Test is a sensitive assessment. Conditions should be perfect when administering the test to a patient. Environmental factors can change the appearance of the test, affecting the results. The room where testing takes place should be adequately lit by daylight, as electric light or direct sunlight could affect the appearance of the cards (Ishihara, 1970, pp. 1-6). The cards should be held 75 cm from the subject's eyes and presented perpendicular to the line of vision so that the plane's normal matches the visual line. The book of test plates should be kept closed as much as possible to prevent the colors and pages from fading in the light and kept as clean as possible. These particulars raise a concern. Ideally, a short version of this test will be given in the initial online screener survey to assess one's ability to see color. Changes in monitor brightness, contrast, quality, and gamma may render the test ineffective, so this approach may not suffice.

Traffic signs are designed to accommodate people with colorblindness. Though red-green color deficient people cannot differentiate between the stop and go lights on a traditional American traffic light, the position of the lights on the device indicate which one is lit (Castro & Horberry, 2004, pp. 77-78). For colorblind drivers, the traffic light lacks the profound effects of color psychology, but the disability still allows drivers to differentiate between lights. Since red is an attention-grabbing, alarming color, it alerts the drivers that they must stop. Green is a calming color, so it is a fine choice to indicate that a driver may proceed as usual.

As previously noted, the normal trichromat is the eye's ability to analyze three color variables. People with color vision deficiencies may lack the ability to utilize the entire trichromat (Jacobs,

1981, pp. 23-32). Anomalous trichromacy, dichromacy, monochromacy, and other forms of defective color vision can alter one's perception of color.

Myopia (nearsightedness) and hyperopia (farsightedness) are two common eye conditions that often come with age (Castro & Horberry, 2004, pp. 116-117). The former is the inability to focus on distant objects, and the latter the inability to focus on near objects. People of any age could have either hindrance, so it is essential to accommodate these conditions in many situations. For the purposes of this thesis, the icons are presented large enough, under standard browser and display attributes, to accommodate myopic and hyperopic participants.

Developing Clear and Intuitive Icons

Icons are intended to be unambiguous. Following a set of guidelines can help ensure that icons are designed in an interpretable manner. Icons should be understandable, explicit, informative, distinct, memorable, coherent, familiar, legible, few, compact, attractive, and extensible (Horton, 1996, pp. 371-372).

Horton's Checklist

Horton developed a checklist based on his philosophy (Horton, 1996, pp. 371-372). It is a tool for designers to ensure that their icons are designed properly.

Understandability is a measure of one's capacity to make sense of an abstract figure. Icons are visual representations, and this indicates how well a viewer can interpret the message (Horton, 1996, pp. 371-372). If an image is accompanied by a label, it, too, will need to be clear.

Unambiguous icons typically demonstrate only one concept, and each concept should only be associated with one image (Horton, 1996, pp. 371-372). He proposes using additional signs or symbols on icons to clarify any remaining uncertainty of the icon's meaning. An explicit icon is unmistakably clear and understandable. It may have emphasized features or contain certain elements that would make the image more identifiable.

Informative icons illustrate their function. The action or motive the icon represents should be entirely clear so the viewer is not taken by surprise (Horton, 1996, pp. 371-372). The icon should serve some importance. If it is in with a group of others, it should be distinguished in some way. If it is a button on a software program or a symbol on a bathroom door, the function should match the representation.

A distinct icon is identifiable and easy to differentiate when among other similar symbols (Horton, 1996, pp. 371-372). A symbol with an arrow may be unclear but if mixed in with a group of icons with the same arrow in different directions, the meaning may become clear. Sometimes the figures should have distinguishing features that make it unmistakable such as increasing the size of certain features or highlighting a particular part with a different color.

Memorability is significant in most cases. The better one can remember an icon and associate it with a meaning, the more understandable it is (Horton, 1996, pp. 371-372). The image should be vivid and, in some cases, associated with a label for further clarity.

Coherency is an issue with many icons. It should be obvious that an icon is its own symbol and not part of any other icon or part of an overall aesthetic design (Horton, 1996, pp. 371-372). The symbol should have a level of detail necessary to inspire the proper interpretation. Many icons are excessively detailed or far too caricatured to be understandable.

Familiarity is frequently practiced in icon design. An icon may represent a common object, such as a phone, and possibly serve a similar function to its realistic counterpart (Horton, 1996, pp. 371-372). Clicking a phone icon will probably open a communication program or display a phone number. However, people may be able to identify an old-fashioned rotary phone more easily than the silhouette of a modern cellular device, as the rotary phone has a distinct shape and most users are familiar with that technology.

Legibility makes an icon easier to view. If the shapes and lines are distinct and figure contrasts with ground, the icon will be much easier to see (Horton, 1996, pp. 371-372). Some icons will be seen in unusual conditions, such as if the monitor has a better or worse than usual resolution, environmental factors cause visual disturbances, or the viewer has a vision impairment or is too far or too close to the monitor to view it properly. Legibility accounts for these conditions, making the icon visible in virtually any setting.

The fewer icons used the better. All icons should be necessary and relevant to the task (Horton, 1996). Horton states that designers should use 20 or fewer icons per group, but the psychological rule of chunking suggests no more than nine groups. The meaning or function of all icons should be detailed in an external manual or guide (Horton, 1996, pp. 371-372).

An icon is compact if every shape and detail in the image is necessary. All superfluous pixels, including borders, added details, and colors should be eliminated (Horton, 1996, pp. 371-372).

Some icons are better represented by words. If the icon takes up more real estate or is too ambiguous, using words may be the best approach.

Attractiveness is important to the overall visual appeal of the system. The icon should be clear and crisp and match the format of the surrounding graphical details (Horton, 1996, pp. 371-372). It should obey a color scheme and share properties with the style such as fonts, rounded corners, or line thicknesses. The images should flow and seem like they belong in the space allotted.

An image's extensibility will aid the icon's versatility. If the image can be resized and still be recognized or changed to a black-and-white or more simplistic representation and still hold its original meaning, it is extensible (Horton, 1996, pp. 371-372). The flexibility of an image may also be an asset if it is used in other media or in multiple places. It may also serve other purposes in different disciplines.

Not on Horton's checklist is a determinant for how long it takes the observer to interpret an image. Clear images should take a short time to identify or label. An image may be clear and obvious, but the user may stare at the icon for a while trying to decide between two definite terms. Comprehensible icons are instantly recognizable and interpretable.

Evaluating Guessability: Iconography as Language

Innatists believe that people are born with an ability to understand and comprehend language (Lightbown & Spada, 2006, p.15-17). The child begins with a template that describes how a language is supposed to flow. People later learn the details of language such as words, structures, and grammar. Noam Chomsky, renowned psychologist, challenged the behaviorist views with this theory, arguing that there is too much for a person to know to be able to piece together parts of languages just by listening to speech. This school of thought suggests that this language template is universal. Basically, all languages stem from this biological understanding.

In the English language, prefixes and suffixes can alter the meaning of a word. As previously mentioned, adding "re" or "un" to the beginning of certain verbs gives them a new meaning. Adding an "s" to certain nouns expresses the general quantity of the subject. Adding "s" to the end of the word "bird" changes the meaning from a single bird to more than one. Such concepts should be applied to icons to help improve guessability or the capability to estimate a picture's meaning based on the knowledge of certain symbols added to or removed from the icon. An image may contain a picture of a pencil when it involves writing. The user may understand this symbol to mean to write or produce. However, if a set of symbols breaks this pattern, the

symbols' meanings become difficult to learn. Children learning the English language sometimes oversimplify, adding "s" to the word "goose" to represent more than one goose. The correct word is "geese," but this is confusing because it breaks an expected pattern, thus hindering guessability. The word "gooses" would be an appropriate assumption based on the nature of the suffix "s," but it is not the correct use in this case. Ruining the guessability pattern will also hamper user confidence, and the viewer may be less likely to assume a meaning for the next symbol presented.

One way to devise understandable symbols is to develop methods for consistency. Icons should have a set of agreed standards by which designers abide. Researchers are attempting to create a systematic approach to icon development (Dreyfuss, 1984/1972, pp.26-31). Symbols are a language of their own and represent objects and actions pictorially. Languages have several guidelines that give words clearer meanings. English uses phonemes and characters, most of which alone have no meaning. Such a system is the morphemic system of the English language. The speaker understands what these pieces of verbiage mean when attached to other words. Instead of having to learn the word "do," "undo," and "redo," one need only understand the word "do." The prefixes "un" as a form of negation and "re" to mean repetition have been previously established (Kucer, 2005, pp.35-38). This is how symbol developers create learnability within a library of pictures. Applying morphological awareness principles to a rudimentary iconographic library could form a reliable foundation for structuring other icons.

In languages, there are frequently inconsistencies in the rules. For example, adding "s" to the end of a noun usually changes it to plural. This does not apply to all words, for example the plural for deer is also deer. Some people learning the language will encounter difficulties when learning which words take on a plural form other than the typical appending of "s." The silent "e" also causes problems. Some beginners add an 'e' at the end of many words when realizing that some words, like "take" and "make," have a silent "e" (Kucer, 2005, p.264). This is commonly referred to as overgeneralization. This shows that people expect regularity in language. In order to avoid this inconsistency and confusion in icons, designers should recognize a set of uncompromising standards. As in language, some exceptions may be established when necessary.

All languages arrange characters in a sequence (Massironi, 1937/2002, pp. 62-64). Some languages are written to move left to right, right to left, or up to down. Each arrangement is readable without much effort. An experiment was conducted that involved changing the logical arrangement of letters in a word. Instead of the next letter in the word succeeding the previous, they were written in a spiral motion; the second letter would be written behind the first, the third at the beginning, the fourth at the end, and the pattern repeats until the end of the word. Therefore,

the word “TOGETHER” would read as “RHEOTGTE.” Although all the letters exist in a decipherable pattern, the words are difficult to read for various reasons. The beginning of the word is difficult to spot because the first letter is hidden in the center. Another problem is that the reader must continually move left and right to read the word. The spaces also get gradually larger as they read more into the word, making it harder to locate the next letter, increasing reader fatigue. In regular text, the space between letters is consistent, therefore requiring the same cognitive resources to study each character. This obscure sequence also requires short-term memory, as the reader must strain to memorize all letters read over the time it takes to read the word and must remember which letter was read previously so he or she know his or her place in the word when looking at the opposite side.

The text arranged in this pattern is incomprehensible because it can no longer be recognized by the human cognitive system (Massironi, 1937/2002, pp. 62-64). This spiraling sequence violates two laws of fundamental psychology: proximity and continuity of direction. These rules are necessary to make decoding written information quick and effortless. The letters must be near each other and arranged in an easy-to-follow, continuous manner.

A difficult arrangement of letters also makes reading through occlusions harder (Massironi, 1937/2002, pp. 62-64). If part of a normal sentence was covered or had letters missing, human cognition may be able to compensate for the lack of information and decipher the word. If such an obstacle was added to a sentence using the spiral arrangement, it would be much harder to read. Basically, the spiral rule is difficult because it requires too great a cognitive load. If the reading process is more natural and requires less effort, the reader will have the means to read past the occlusion. The predictable flow of perceptual units allows the reader to focus more on the symbolic meaning of words without much visual cognitive effort.

In many languages, one word can have several meanings that change depending on the context (Massironi, 1937/2002, pp. 62-64). Usually they are separated into semantic and material groups. Saying “This is a glass of water” uses the object “water” as a noun. A similar sentence, “This water glass is full” uses “water” as an adjective to describe the glass. The word is the same but takes a different meaning because of context. The former refers to a physical object and the latter qualifies a particular type of object.

If one were to design an icon to express the action “Create Circle by Points on Diameter,” an artist can combine understood symbols to show the object, the action, and the method. The object is a picture of a circle. The action is “draw,” depicted by a pencil. The same pencil should appear in a different icon to represent the action “draw” also. There are several ways to form a

circle in this program. The illustration shows two opposite points on the circle's diameter to express the method "create circle by opposing points." An illustration expressing "Create circle by center and edge point" will have the same object and action depiction, but the method would be represented by a dot in the center of the circle and another on the edge (Horton, 1996, pp. 371-372).

This concept is widely accepted as an appropriate means to create language. Several languages worldwide use this sort of repetition in order to improve learnability and comprehensibility. It also saves one from having to memorize many different words and meanings. Languages such as German, Spanish, and Latin change the end of the word based on the gender of the object to which the word refers. American Sign Language repeats symbols in certain words to clarify context.

Certain symbols are used frequently and usually conjointly with other symbols to change meaning. The results can be prohibition marks (usually indicated by a diagonal line or "X" through the original symbol), restrictions (when the icon is within a circle), warnings (when the icon is inside a triangle), and directional symbols (usually indicated by arrows) (Dreyfuss, 1984/1972, pp. 26-28). This thesis will test these semantics in the experiments by including them within certain symbols. The original symbol (without the modifier) may be included as a control.

Combining icons is a common practice. A symbol of a bird, depicting all notable physical features that make it recognizable could have a different meaning if combined with another symbol (Dondis, 1973, p. 72). If the same silhouette were shown carrying an olive branch in its beak, it would represent peace. Since the dove is a bird frequently associated with peace, viewers may identify the generic bird shape as a dove. With the addition of a minute detail, the icon's meaning changes.

One study investigated whether Taiwanese computer users could correctly identify English-created icons on a computer (Wang, 2007, pp. 199-202). The test investigated the variables of computer experience and knowledge of the English language and concluded that knowing English had little effect on the ability to correctly identify the icons. Computer experience was the main factor. Some of the icons such as "underline" (depicted as the letter U with a line underneath) used English characters. A study of English users with little computer experience showed that participants had more difficulty identifying icons with English characters on them than their more tech-savvy Taiwanese counterparts. Basically, language was not the primary factor in assessing one's ability to correctly identify concrete or combination icons. Regardless, using specific characters can add a variable and bias the results.

Young viewers understand the concept of combining different icons to form one with a new meaning. An author describes an instance of how people interpret icons differently if used with other symbols. Children identified skull and crossbones as a pirate symbol. When a bottle was drawn around the figure, the same audience described it to mean “poison” (Dreyfuss, 1984/1972, p. 142). This symbol has been accepted to represent mortality since the 16th century (Miller, Brown, & Cullen, 2000, p. 49) and has been embedded in popular culture, keeping it exposed to the public in books, movies, and music. This icon has taken on the meaning of death and destruction in most of the world but still holds a promise of good fortune in Tibet and Nepal.

Researchers have examined the interpretability of icons across various cultures. One study tested cell phone icons with varying levels of detail among Americans and Koreans (Kim & Lee, 2005, pp. 307-310). The conclusion was that Koreans prefer more concrete icons, while Americans prefer abstract. This demonstrates detail preferences among certain cultures.

Communicating Through Analogy

Analogies are cognitive processes that use alternate subjects to describe or represent a source topic. Typically, analogies are used to support a description of the source that may otherwise be too abstract to understand easily. Analogies can exist linguistically, visually, or in a multitude of other ways.

Analogies are commonly discussed in literature and writing, for example, a writer comparing a series of streetlights to lights in a night sky. Both are points of light. Each is only visible at night and invisible when morning approaches. They are usually above the observer’s head, and they light in a predictable pattern. They also both eventually burn out. Therefore, a reader may understand the reference. Analogies are used to make writing more appealing, adding color to a piece of work. They also help explain an abstract concept. William Shakespeare’s famous poem, “Sonnet 18” is an analogy comparing a woman to nature.

Neils Bohr’s model of the atom is an analogy that demonstrates the physical characteristics of an atom and its subatomic particles. His comparisons of the atom’s makeup and physics to the patterns of the solar system made his representation easier to grasp. Bohr took an unfamiliar concept, the structure of an atom, and compared it to something the audience knew, the solar system. If the nucleus was seen as the sun and orbiting electrons as planets, people were better able to grasp his concept. The model was a much simpler version of the atom’s actual physical properties but illustrated the complex concepts in an easy-to-understand manner.

Among the best analogies in the field of usability engineering is the desktop metaphor used for many computer operating systems (Hamilton, 2000). The introduction of the mouse and graphical user interface, or GUI, spared users from typing complicated and frequently long strings into a command prompt. Users would typically err when typing commands, resulting in more wasted time in retyping the string or worse, causing the computer to crash. The chance of error is much lower when a user clicks on a word or icon to perform an action. Most computer operations required a manual to perform the simplest tasks. Computers required an investment of time and training to understand the system, a tradeoff few were willing to accept. The mouse and the GUI improved interaction. This lowered the time needed for an operator to advance from novice to proficient, reducing the cost of writing, printing, distributing, and maintaining documentation. Users unfamiliar with computers had difficulty understanding their complex functionality. The desktop analogy helped simplify the processes by relating the abstract practice to a familiar concept. Using a metaphor to represent a task such as the computer screen mimicking a desktop in an office environment, adds a familiar mechanism to an unfamiliar situation, facilitating easier learning. Apple's trashcan icon allows the deletion of a file by clicking and dragging the file to the can, just as an office worker would do to discard any paper. Sometimes metaphors mislead. The user performs the same action to eject a floppy disk, moving the disk icon to the trashcan. One would see this as deleting the floppy, when in fact it merely removes the floppy for later use (Hamilton, 2000). Few peculiarities may cause initial confusion. However, users acknowledge the ambiguity and shortly accustom themselves to the interface. Platforms still use the desktop metaphor with icons and windows displayed on the screen. Designers have since refined the interface to handle greater functionality and improve intuitiveness. The metaphor was a massive success that dramatically changed computing for the better. Xerox competitors adopted the concept and designed similar mouse-controlled GUIs in support of its function. As a result, computers became easier and quicker to learn and use, providing a richer, more fulfilling experience.

Visually, icons can be analogical. A blue icon could represent a low temperature, as could icicles or a thermometer with low mercury. An image of a giant could be used to represent a function that makes something bigger. A picture of a magic wand could symbolize a "wizard," which, in software terms is a system that guides a user through a complex process with separate steps. Though these icons do not directly describe the process they represent, the designers expect viewers to associate the symbol with a certain procedure through analogy. This approach may work well for some viewers, but many may be confused depending on the analogy. Usually, the reference is chosen based on popular culture and experience. The associative process is complex, as it usually takes more than one step. For example, the user would need to identify the wand to be a magic wand, then associate that to a wizard, who, using recall, is then associated to

the wizard computing tool. If any one of those references cannot be identified, the icon fails to do its intended job.

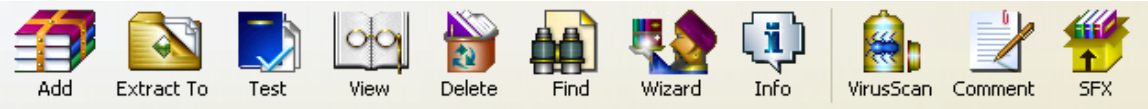


Figure 13 – RARLAB's Detailed Icons

The standard toolbar in RARLAB's WinRAR application (Roshal, 2008). Some buttons use analogical icons to communicate their functions to the user.

RARLAB's WinRAR software application employs many analogical icons (Roshal, 2008). The images on buttons in this software are more detailed and colorful than most professional software icons as shows in Figure 13. This software uses icons such as a depiction of an actual wizard to reference the wizard tool. This is a very ambiguous image, as the wizard looks like a genie, gypsy, or other character. The attention immediately goes to what the character is holding (which is depicted as a zipped file), rather than the character himself. The developers place the word "wizard" underneath the icon for clarification, a last resort to convey icons which are doubtful in meaning. Still, those not familiar with the wizard approach to computing may be unclear about what the button does. Another icon in this program is a button that contains an image of a spray can with an insect on it. This is another analogy, as it represents a VirusScan function. A virus is the generic name given to any problem with a computer's software. The virus scanner checks for these errors and usually repairs them. The virus is typically depicted as an insect, but many viruses are also referred to as "bugs," referencing Grace Hopper's encounter with a moth which caused problems in one of the first computers. The insect on the can represents this. The can is supposed to represent an aerosol-powered bottle of bug spray, which is used for killing insects. This complicated analogy depicts a bug on a spray can to represent VirusScan. Therefore, one must identify the can as a spray can that does a certain task. The viewer will see the bug on the can and understand that it means virus. Since the virus image is on the can, it must be a can of chemicals that kill viruses, and, by clicking the button, the software will search for mistakes in the files and repair them. Fortunately, the design incorporates the word "VirusScan" below the icon. These icons appear grossly unintuitive. Analogies are intended to make descriptions clearer. If used improperly, they may make an association more complicated.

Why Understandable Icons are Important

One downfall for companies that develop graphics for their products is that their creations are not tested. Theorists like Everett Rogers and Douglas Liddle wrote extensively on the subject of technological adoption. Liddle's philosophy lists three phases that a product goes through when released to the market: enthusiast, professional, and consumer (Moggridge, 2007, pp. 244-249). The enthusiast phase is composed of hobbyists or people who appreciate a tool for the sake of technology. Only those who are willing to invest the time and energy in learning and preparing such a system are the ones who will use it. Members of this group usually do not care too much about a system's usability or reliability, as the challenge to master the technology is part of the pleasure. The professional phase involves the people who use the technology for business purposes. Companies must usually stay current with technology in order to remain competitive. Businesses have enough venture capital and labor to risk with a new technology. Usability is not a high priority, as some workers take pride in the complexity of the tools they use in their job. Contrarily, improved usability should increase efficiency and reduce user frustration. The public comprises the consumer phase. People will buy a product in this phase when it can enrich their lives in some way. Consumers care about a product's usability, appearance, reliability, low cost, availability, and several other factors that were not relevant in previous adoption phases. Therefore, when the technology is refined and becomes reliable and affordable enough for the consumer phase, software developers will understand the appropriate methods to build a system to accommodate the new technology. The problem with many software developers is that they are in a rush to market a product and, therefore, invest insufficient resources (Marcus, 2003, pp. 37-43). As a result, they must hastily produce visual icons before the release.

Designing for Universal Understanding

Many designers attempt to create icons that are understood by all. It is difficult to measure how effective these icons are, but certain case studies offer insight. Cultures have different opinions about what symbols mean. Hand gestures vary across demographics. Holding up the palm of one's hand usually means to stop or halt, but is an offensive signal in Greece (Horton, 1994, p. 245). Safe visualizations of hand gestures include holding, pressing, or moving objects. It is also dangerous to use body parts in symbols. Sometimes feet imprints are used to represent a move forward, but in the Orient, bare feet are offensive and unclean (Horton, 1994, p. 249).

Oftentimes people encountering a symbol may share a commonality. For example, American office workers may be familiar with the same tools as their international counterparts. Therefore, icons depicting familiar objects such as clocks, calculators, or cardboard boxes will keep their

connotation across cultures (Horton, 1994, p. 260). Those unfamiliar with office supplies may not understand the reference.

Cross-cultural interpretability is important for any icon that will be used by more than one demographic. A package traveling from Moscow to New York had three symbols on its side: two upward pointing arrows to represent “this end up,” a wine glass with a break in it representing “fragile,” and an umbrella in the rain depicting the instruction “keep dry” (Dreyfuss, 1984/1972, p. 99). This package traveled to Constantinople, Piraeus, Genoa, and Lisbon. These icons had to make sense to speakers of at least six different languages.

Similar Experiments

Image Quiz by Games for the Brain presents a user with multiple images from Google Image Search (Games for the Brain, n.d.). Grant Robinson’s Guess-the-Google is similar but programmed in Flash (Robinson, 2008). While the games are purely for entertainment, they exhibit a relevance to my intended procedure. The player must guess the search query that returned the images. The user sees several images and must derive the property that they have in common. If the participant is correct, the game awards points. If incorrect, new images appear. If this idea were turned into an experiment, it could show search engine developers how to create more relevant search results. Instead of asking what all images have in common, this thesis asks users to define images individually. It allows the person to decide which answer is correct instead of rewarding him or her if the answer matches the query.

Carnegie Mellon’s Gwap site features the “ESP Game,” which requires two simultaneous players to label the image presented on the screen (Carnegie Mellon, 2008). This is similar to Google’s Image Labeler (Google Image Labeler, 2007). Entrants are shown an image and must suggest words that they feel best describe the picture. The site will list “taboo words” that cannot be submitted. In order to win, both players must have typed the same words. The game requires two players to think alike and come to an agreement about how an image should be interpreted. This experiment is similar, except participants do not have to agree. It also researches icons, not photographs. Having players agree on a description creates more relevant tags and helps eliminate ambiguous or bizarre tags.

The web interface for this thesis will calculate and organize the responses for each graphic. It will show which terms were used most often and rank all responses accordingly. The most obvious and comprehensible interpretations will occur more frequently and will show at the top of the list.

Instead of comparing the tag between two participants, this approach compares it to all other user responses.

Researchers have performed a trial that attempted to explain how the brain identifies a scenic location (Greene & Oliva, 2008). Their paper researches how the brain takes abstract visual information, such as a photograph of a natural setting, and turns it into a recognized format. This experiment consists of four parts, each contributing data helpful to reaching an understanding of the brain's ability. The goal was to analyze how people classify the setting for each image shown. Some were clear such as a land of grass that would most likely be classified as "field," and some were more ambiguous and open to interpretation, such as a body of water surrounded by sand that could be either "desert" or "lake." The first experiment involved users classifying images according to one specific global property. Seven properties were tested: openness, expansion, mean depth, temperature, transience, concealment, and navigation. Sorting by temperature, for example, would yield a screen with warm images such as brightly lit scenes and desert depictions on one side and cooler scenes such as wet areas and tundra, on the other. The second experiment tested how well the participants were able to determine the setting when presented with one image at a time. The experiment's purpose was to test whether participants were more likely to confuse images with similar rather than different global properties. For example, people may confuse oceans with fields since they both have a high degree of openness, but they can probably distinguish between areas of different openness qualities such as a close-up of a waterfall and a wide shot of a desert. Experiment three uses the data from the first set of trials. Instead of the participant looking at an image, they are given the classification information from the first experiment to try to determine the scenes. These results were compared to the second experiment, where participants saw only images. A fourth experiment was conducted to see how people identified each area in the image, thus revealing how someone would conclude such an interpretation of the location. Each participant was asked to trace separate regions on an image and identify what each region represented (such as mountains, clouds, sky, water, and grass). Basically, these experiments developed a way to classify scenes based on global properties.

This experimental investigation seems to resemble the typical Rorschach test. Instead of looking at abstract, random blotches in an attempt to learn more about the human psyche, this experiment investigates an interpretation of forms for practical application. A Rorschach exhibit contains random images presented in a particular order and format. Subjects express their thoughts about each image; particularly what they look like and how the image makes them feel. Participants are allowed to handle the images. Each image is presented in a certain color. Most images are black, but some contain a variety of color. The images remain the same colors for each participant. This test also takes more into consideration than this experiment and is far more

subjective. The administrator is usually more concerned with how a participant responds rather than the actual response.

Improving Usability

Technological innovations can dramatically direct public purchasing and affect corporate financial health. New paradigms constantly emerge in computing, revolutionizing how people interact with machines. Innovative interaction technologies make personal computers more user friendly and popular, thereby increasing revenue for the manufacturers. Computers become easier and quicker to learn and manage, providing a richer, more fulfilling experience for the user.

Though there is a high initial investment in developing a new idea for interaction, the result can yield a notable profit. The typical return on investment for usability engineering is $1: $10-$100, meaning that for every $1 invested in improving a technology's interface, the organization profits from $10 to $100 (Bias & Mayhew, 2005, p. 19). Some cases have proven to have an even greater return, reinforcing the effectiveness of proper usability engineering practices.

The benefits of usability engineering for vendor companies is that it can increase sales, decrease customer service calls, increase savings from making changes early in development, and reduces the cost of product training (Bias & Mayhew, 2005, p. 56). These numbers are objectively measured, collected, and studied in monitoring the success of a new product. Ease of use can also work as a promotional tool. Many product development companies invest more time and budget in utility than usability, often undermining the importance of interaction (Bias & Mayhew, 2005, p. 188).

Evaluating Usability

Heuristic Evaluations

Jakob Nielsen developed 10 usability heuristics to improve product development (Stone, Jarrett, Woodroffe, & Minocha, 2005, pp. 525-537). Usability engineers can follow these guidelines to increase a system's ease of use. Performing the evaluation is quick and simple and usually requires the labor of one or a small team. It does not cover every aspect of usability, but it is a valuable tool when developing a product to catch any significant usability issues before starting more advanced and expensive testing.

It is a wise economic choice for developers to perform heuristic evaluations on their products and consider Nielsen's 10 guidelines when developing new interfaces. Heuristic evaluations are merely observations of a system's components. This can be done in a relatively short amount of time compared to other methods for refining interfaces such as usability tests and focus groups. There is usually no material or spatial requirements, which make the analysis low in cost and quick. The low-cost analysis can yield tremendous benefits. A simple evaluation could reveal major flaws with a device or suggest ways to improve the desirability of the product to the intended demographic. This evaluation is most useful and cost effective when performed in the design phase of the product development lifecycle. Research shows that most product changes are currently made in the production phase (Bias & Mayhew, 2005, pp. 274-276). Making changes in the design phase is less expensive because the idea for the product is still under development. The design team is not yet invested and attached to a single proposal, which makes it easier to suggest modifications. The details of the product have not yet been specified, so that changing features would not require reworking a model. If alterations are made in the design phase or post-design phase, it may be necessary to stop development and change the product, which would cost additional time, money, and labor. Sometimes changes suggested when the product is in these phases are ignored and reserved for the next version of the product. Therefore, the benefits of performing heuristic evaluations are well worth the costs.

A heuristic analysis is a superficial approach to identifying a product's drawbacks. A usability study is a more refined, in-depth method (Straub, 2003). This approach is acceptable when one needs to identify flaws in a system if allotted a modest budget and little time. Jakob Nielsen demonstrates the effectiveness of heuristic evaluations with a case study (Nielsen, 2005). The costs for performing the evaluations were about $10,500, but the expected return on investment was $500,000. Heuristic evaluations will not identify every fault in a product. Despite incomplete results, it should reveal a product's major flaws and possibly illustrate problems that a typical user might encounter with the system. Certainly, the more evaluators assigned to finding the errors in a system, the more it will cost and, theoretically, the more they will uncover. Nielsen devised a formula for predicting the number of errors that a team of experienced usability engineers would find. Based on his calculation, one evaluator would reveal about 35% of the errors. The more evaluators assigned to a project, the more faults they will reveal, but the fewer unique errors each evaluator would notice. Therefore, the ratio begins to level. Nielsen shows a graph of the ratio of costs to benefits and illustrates that it is most cost effective to have three to six people perform the heuristic evaluation. Fewer evaluators will not catch enough errors to yield high benefits, and more than six would not find enough unique problems to be worthwhile.

Surveys allow administrators to collect both subjective and objective data. The presence of an administrator is not necessary, as the surveys can usually be taken by mail or online. If completed online, several administration tools can sort, count, and manage the data from surveys submitted by the users. Online surveys can also preserve confidentiality, manage the data in a secure manner, and ensure a quick turnaround. A computer-managed survey is much faster, as computers can immediately tabulate all responses in a statistically relevant manner. This thesis will investigate a user's perspective on images through an online tool for these reasons. For such a test, it is not necessary to have an administrator present.

To help ensure a product's success, it is important to understand the customer's needs before development. Technology adoption is the study of how a population accepts a product. If manufacturers analyze the user's needs and wants, the product has a better chance of succeeding in a competitive market. Several variables determine adoption in a community such as product awareness, price, reliability, functionality, and popularity. Many theorists, such as David Liddle, as previously discussed, developed adoption schemes that outline how a group of people will accept a new technology.

Improving icon understandability is economically wise. Proper iconography can make a product more desirable and cause fewer problems during operation, improving sales and reducing maintenance. Though some products have further revisions and improvements after an initial version is marketed, using appropriate icons initially will improve later iterations. This also reduces time and other costs needed to revise a product and enhance its usability. It will also give the product a competitive edge in an aggressive market.

Nielsen's Ten Heuristics

Since icons improve usability, it is necessary to discuss how professional usability practices contribute to the effectiveness of a system. Icons can assist in improving ease of use for most systems.

As previously noted, Jakob Nielsen, renowned usability expert, has developed a system of ten rules to assess the usability of a system (Nielsen, 2005). He has published these rules in his work and referenced them in others. Many publishers have included his insight in their texts as well, testifying to the validity of his system. Nielsen has also posted this on his personal website, useit.com, for global, immediate access to this valuable resource.

To quickly assess the intuitiveness of a system, a trained usability professional should observe an interactive system and respond to the following evaluative heuristics: visibility of system status, match between system and the real world, user control and freedom, consistency and standards, error prevention, recognition rather than recall, flexibility and efficiency of use, aesthetic and minimalist design, help users recognize, diagnose, and recover from errors, and help and documentation.

Though these heuristics were designed to assess a complete system, they can apply to the development and implementation of icons and symbols on interfaces such as computer applications. It could also pertain to the roles icons serve in an interface.

Visibility of System Status

Systems are usually state based such as a Boolean expression (true or false, on or off) or a count (temperature or population), so it is often important to report that state to the user. Icons may need to reflect this.

On personal computers, the cursor is usually the main tool for interacting with the operating system. Owners use this tool to change the state of the machine by clicking buttons and performing other actions specific to a task. When a user requests that the computer perform an operation, the cursor transforms, usually into an hourglass or spinning circle, to show that the computer is processing the command. Feedback is important to most interaction systems, as it informs the user that the action has a reaction. The wait cursor illustrates that there is a delay in feedback and the reaction will soon be visible.

Icons are also capable of showing a system's status by modifying its appearance. Some icons show a Boolean state, a value which is either true or false such as an on or off switch, which may have a certain appearance to indicate whether a system is currently running. Some express a range of values. A thermometer icon may illustrate the approximate value of a machine's core temperature. The battery icon that shows the remaining power in most laptops shows how much energy remains in the computer before its battery needs to be recharged. Sometimes icons change their state dramatically to indicate a problem. The battery icon, for example, may appear to have a red "X" over it if the power is low enough for concern. Some icons flash, change size, color, and sometimes verbiage if the user's attention is necessary.

Match between System and the Real World

The system should be presented in a way that is easy to understand for the user. The language should be clear and understandable, using terms and concepts that are familiar to the people using it. It should also follow a natural and intuitive pattern so it works as expected. One of the best ways to accomplish this is to map a system to something known. For example, pressing an up arrow on a computer would make something move upward or forward so as to match an established cognitive map.

A car steering wheel is an example. It maps with the real world, turning the car right when turned clockwise, and left when turned counterclockwise. The car's turning radius decreases with the distance of the turn from its original position. The controls are natural and intuitive and for that reason are easy to learn. The system, the car, matches the real world perceived by the driver.

A famous example in computing is Douglas Engelbart's mouse. The engineer, with help from Bill English, developed the idea for a prototype in which two wheels on a device control the x and y coordinates of a cursor on screen (Moggridge, 2007, pp. 15-72). For demonstration purposes, he constructed the first mouse using a hollow box and spare parts. The bulky, cumbrous cube was enough to capture the audience's attention. Xerox gradually improved durability and aesthetics. Engineers contemplated assorted methods of mapping the buttons and proposed alternate shapes. All ideas stemmed from the initial concept of a hand-guided device upon a desk that controlled a cursor on screen based on its position. The position of the mouse on a desktop was a perfect match to the location of a cursor on screen. When the user moves the mouse forward then right, the cursor responds immediately to the movement, traveling up then right. Since the responses are instant, the cursor moves at the same speed and integrity as the user's mouse. Though many revisions of the mouse have been made, the same basic shape and functionality remains almost identical to the original prototype.

In icon development, mapping a system to something familiar is among the most important concepts. Obviously, the icon should be clear and understandable and present itself in a way that the viewer can understand. However, the designer should also consider more unobvious details such as position among a library of icons. If, for example, four icons are buttons that control direction such as left, right, up, and down, they should be positioned respective to each other so that they are intuitive. The top button should move something upward when pressed. Street signs often indicate changes in the consistency of the road such as an intersection or fork. The sign shows a map of the upcoming road condition from the perspective of the driver, where it is safe to assume that the bottom of the sign is the driver's current position. Icon orientation should be

adjusted so that it matches the viewer's perspective. Street signs work similarly. The sign is displayed so that it runs parallel to the street it names. This helps simplify which sign indicates which street and is also visible to drivers traveling perpendicular to the streets.

User Control and Freedom

A robust system supports undo and redo in case the user errs. Users should feel safe to test the system without fear of ruining the functionality, as this is a great way to learn how a system works. Sometimes a user may make a mistake and will require a means to fix the problem or return to the other state without having to work too hard. Therefore, there should be an ever present emergency exit in case the user makes an error. Supporting undo and redo is an effective way to allow users to experiment with a system's functions. If the operator errs, an undo function reverts the system to its normal state.

Icons assist in telling the user what should happen if they perform a certain action. Though the proper way to build systems is so users may recover from mistakes, it is not always possible.

It is expected that a user may err when interpreting an icon. To prevent these errors, some icons are accompanied by other symbols. Others may be explained with words usually written below the icon. Some icons are used jointly with other icons in order to reinforce an idea. A restroom door has male and female symbols to indicate which room is for which gender. Sometimes these icons are accompanied by text stating "Mens" and "Womens" to clarify any confusion. Users are free to enter either bathroom. People seldom select the incorrect facility. If an error is made, they can simply walk out and enter a different one.

Consistency and Standards

Icons should clearly distinguish between others that serve similar functions. The viewer should not be confused about whether different icons have the same meaning, or if one icon can have two different meanings. An icon that shows a silhouette of a man may not be obvious, but next to a silhouette of a woman such as on a bathroom door, it represents men. There should usually be only one icon for every action. For example, an area should have only one particular road sign to represent "stop." If some roads used a red hexagon with white lettering and others used a green circle, and both were to indicate that the driver halt and yield the right of way, the system would be confusing. The driver would have to learn two symbols and often question if there is a difference between the two. If an electric device had a green diode light when it was on, it should only remain lit when the device is operational. If the same green diode lights when the device is

charging, for example, the symbol would represent two concepts. This may be difficult for the user to grasp, as the icon will have two different meanings, and it is up to the viewer to search for other cues such as the cord being plugged in to an outlet, to figure out which meaning is correct.

If a certain discipline is adopting a particular library of icons, it should stay within its standards. It is easier if the icons are an accepted standard by which all in the group must abide. This will keep communication clearer between people in a certain discipline. For example, all icons may be presented in a one-inch square, or all figures in an icon are beveled, or the series uses certain symbols to show prohibition and allowances.

Error Prevention

Users can make mistakes. It is essential for a system to prevent against errors as best as possible. Error messages and supporting an undo function are means to recover from malicious yet unintentional mistakes. The best approach is to design a system carefully so that such problems are prevented.

Usability is important because it reduces the amount of errors a user will make when using a system. This is another reason why clear and intuitive icons are necessary. Nielsen suggests trying to eliminate conditions that may cause confusion and error. Of course, this is inevitable. He also recommends adding a confirmation option so users can verify their actions before committing to them.

On most computer systems, the action is performed on mouse up. This means that on a click of a button, the action is not initiated until the user releases the button. This gives the user the opportunity to move the cursor off the button if it was clicked in error. Some icons may even change appearance, such as color or bevel, when clicked. This also indicates that the operator has begun an action.

A computer mouse allows the user to interact with visual elements through clicks. The user moves the mouse, which controls the cursor on screen. Clicking the mouse will perform an action on the object the cursor overlaps. However, if the user clicks in error, the user is able to recover by moving the cursor off the object before releasing the button. The action is performed on the release of the button, not the press. This allows the user to adjust the command before it is finalized.

Icons prevent against errors as well. The best means to prevent against interpretation error is to design an effective icon. However, all icons are open to interpretation. To eliminate confusion, some icons are accompanied by the meaning of the symbol. A men's bathroom may have an icon that looks like a person with the word "mens" adjacent to the symbol to eliminate any confusion. This is particularly important with hazard warning labels such as for flammable or explosive materials.

Recognition Rather than Recall

This method states that systems should rely on a user's present knowledge, not memorization. All systems should demand minimal cognitive load, making objects, actions, and options present instead of relying on memory. Systems should be intuitive and not require an operator to learn new procedures. Users should know where to retrieve additional information when necessary.

In terms of icons, this guideline refers to designing icons so they are easy to identify, not easy to remember. Many icons are understandable because people have been taught that they represent something in particular. For example, it may not be clear that a yield sign means that one should give the right of way to any oncoming traffic or that the jagged lines on a wire in an engineering project represent a resistor. These signs are learned. People recall them when needed. Some icons such as a picture of a telephone, are instantly recognizable and do not require much learning. However, the viewer must know what a telephone looks like and what purpose it serves before being able to make sense of the icon.

Flexibility and Efficiency of Use

Many systems, particularly software applications, change to accommodate experienced and novice users. Beginners may need more guidance and, therefore, an application may hide advanced settings, offer more textual support, and increase the number of steps required to complete an action. As a user becomes more familiar with the software, it may be more efficient to have the system arranged in a different manner such as by making frequently used functions easily accessible (usually by learning a keystroke). The user may also tailor the application to reveal more advanced options and reduce the text guidance. These are called accelerators: tools which hasten the ability for users with more expertise to use a particular system.

Icons function similarly. Some include a short text description close to the icon to reinforce what the icon represents. Users familiar with the icon may simply look at the picture and understand it.

Someone unfamiliar with the icon may read the description or reference a provided key to learn what the image represents.

Aesthetic and Minimalist Design

If a system contains an overabundance of information, it usually hinders usability. All extra information competes with important elements and lowers their visibility. Irrelevant information should be eliminated. This is true with icons as well. Icons containing superfluous detail are more difficult to read and understand. The clearest icons are typically the ones that are simple but reveal the important characteristics of the concept they represent. If one were to design a symbol for a bus, the level of detail would be an important consideration. A highly detailed, neatly photographic drawing of a bus would be unclear and take the viewer too much time to see what the picture represents. However, a drawing too simple, such as a horizontal rectangle, would be unrecognizable. A fair exchange would be a rectangle with circular wheels, a few simple windows, and a longer rectangle to represent the door. This would be clear enough for most viewers.

This principle also applies to the number of icons presented. At an airport, it is not necessary to display separate icons for food, drinks, appetizers, coffee, and donuts, when they can all be grouped together with a simple restaurant icon. When the traveler follows the restaurant sign, then the next set of icons can present more specific information. Sometimes multiple icons are important such as in an art program. The toolbar may contain a large array of buttons that are always present. Finding the appropriate button can be difficult, as humans can only remember between five to nine chunks of information at a time. Instead of keeping the icons in one large cluster, they are usually separated into many smaller clusters according to their functions. Drawing tools such as shape and line stencils, the pen tool, paintbrush, and fill, may all fall under the same group, whereas a group of select tools or modifiers may be placed in another group. This process takes ample information and sorts it in an easy to understand manner, making the program easier for the user.

Help Users Recognize, Diagnose, and Recover from Errors

Nielsen suggests that error messages should be clear and concise and not expressed in a code or language that average users would not understand. Aside from presenting the problem, the system should also explain the problem in as much detail as possible and suggest measures to fix the error.

Icons can help alert users of system errors. A graphic representation of a copier could show the user where a jam is located. Some modern devices also demonstrate what the user needs to do to correct the jam.

An example of this guideline could be a detour sign in traffic. A road construction crew may install temporary signs to override the permanent ones that exist. The drivers will see a symbol that indicates that a road is closed and then see a detour sign that will take the traveler down a road that leads to the same destination as originally planned.

Help and Documentation

Systems should be clear enough without the guidance of a manual or any other operational aid. However, sometimes the operator must consult a help system or document in order to understand a concept or procedure. Nielsen recommends always providing some sort of help with all systems. It should be particularly easy to use and quickly reference the information needed.

If a viewer sees an icon and is unclear of its meaning or purpose, there should be a way for that person to find more information about it. Sometimes designers include a caption near the image to textually describe what is represented in the picture. An icon could depict a car with notable signage on the roof with a text description underneath reading “taxi.” In larger areas, a key or legend could describe the symbols presented on a chart or map. This way the reader knows that a circle inside a star represents a Capital on a political map, or a picture of a dog in a realty guide means that pets are allowed at a particular apartment. In software, developers usually place a description that appears when the user hovers the cursor over a button for a period of time. This is usually referred to as a tooltip but varies depending on the discipline. If a user is uncertain of the action that will result from clicking, the description will add some clarification. In complex machines, a manual will usually inform the operator what certain symbols mean. This typically acts as a guide for understanding the machine. Some help manuals are digital and may be provided in the form of a help menu built into a software, an external PDF, or a website with public or private access. Digital help guides can clarify icons just as well as print publications but on screen they allow the user to search for a particular word or phrase and allow for other bookkeeping procedures like bookmarking and highlighting, thus improving the speed and efficiency of reference.

No matter how the information is presented to the user, it should follow certain conventions. It should be written well, clear, and concise for all readers. Large amounts of text should be

summarized or organized in a bulleted list or chart. The information should be easy to find. The text should focus on the user's task and not contain an overabundance of text.

Application

Applying Nielsen's ten usability heuristics for icon development should improve the design process and make icons more useful and intuitive. Designing the icon properly the first time will eliminate the need for redesign and more extensive testing. Being aware of these heuristics will aid designers in initially developing appropriate icons. Jakob Nielsen demonstrates the effectiveness of heuristic evaluations with a case study (Nielsen, 2005). The costs for performing the evaluation were about $50,000 but the expected return on investment was $500,000.

Latent Semantic Analysis

Semantics is the study of meaning. The word originates from a root meaning to signify or indicate. Depending on the discipline, this word can have multiple definitions, each subtly differentiating the other. The most popular use for the word is in the study of linguistics, where words, symbols, and signs have some relevance to the observer.

When asking people to describe an image, they may use terms that have the same meaning but are different words. A latent semantic analysis, or LSA, is the process of discovering and analyzing vector relationships between documents or terms by using a set of comparisons that relates them to each other (Landauer, Foltz, & Laham, 1998, pp. 259-284). This is sometimes referred to as Latent Semantic Indexing, or LSI.

This concept is derived from the belief that algorithms can mimic human understanding. The structure of verbal meaning could roughly match that of a human's with only one constraint. An algorithm could learn the meaning of words by their association with other contextual clues. Humans learn vocabulary in a similar respect, deriving the meaning of words by their association to words used conjointly.

LSA is a capable tool for assisting in many modern investigations. When supplied with an ample corpus of accurate and relevant text, the algorithm scored well into high-school-level vocabulary on standardized vocabulary tests. The algorithm can also state the adequacy of an essay, matching close to the grade an individual would assign to the text. LSA is capable of stating the coherence and relevance between two paragraphs better than human readers these features may be used to improve writing style. The algorithms are also capable of identifying how well a

student improves over time and has also been noted to diagnose schizophrenia better than experienced psychiatrists. It also improves information retrieval up to 30% by knowing which documents contain similar information, even when the documents have few to no words in common and may not even be the same language, demonstrating that the algorithm is aware of word meanings.

Many philosophers have debated and theorized about the learning of words, language, and meaning. Despite the research and noteworthy predictions, the LSA theory stemmed from a more recent concept that is relatively simple when compared to other hypotheses. LSA is based on the theory that inherent connectionist models were responsible for the learning and understanding of word meaning. Theories state that word meanings are understood through their association with other words. Most theories involve rules and variables, many of which are explained by human judgment. If a mathematical expression was to govern its own understanding of words, the human factor could not be present. This also requires the assumption that humans think and reason alike. However, if the LSA is fed proper corpora from which to learn and derive understanding, the human factor would still be included, assuming humans created the corpora.

As this author understands, the human element is, in fact, present in the mathematical calculations of LSA. Humans write so that other humans understand. Including human-created corpora in an LSA should certainly output words and meanings that are similar to human understanding and match a particular thought process. When one writes a sentence, the elements are typically arranged in a clear and logical format, and certain words are chosen that can best represent the information the writer intends to convey. Therefore, if humans write the corpora, LSA will understand the meaning of words according to that corpus. LSA does not learn on its own. Humans are taught words by rote when they have no other vocabulary with which to compare it. LSA can certainly handle and find word relations to a string of random words but would certainly not derive the same relations as a collection of words that were used properly. If an algorithm was provided a corpus of words from an English dictionary, it would be unable to find meaning among them, as they would all be equally associated to each other. The only similarity they would share is that they are all part of the English language.

The algorithm learns by comparisons and relations, for example, a basic algebraic formula such as A+2B=C. This could yield an infinite solution set. However, if the same variables were used in another formula such as 2B=A, the first expression has still an infinite number of possibilities, but the values of A and B are known with respect to each other, as A is twice B. If the expression 2A=6 is given, this adds insight to the other two formulas, and the values of all variables are now known. A=3, so 2B also equals 3, so B = 1.5, and therefore C=6. LSA works similarly. Words

alone do not demonstrate meaning, but among other contextual cues, the meaning becomes interpretable. The more expressions with which the word is used, the clearer and more refined the definition becomes. The math behind LSA is not as absolute as the math in comparing algebraic expression where the value of the variable is either not known (narrowed to more than one possibility) or known (having only one possibility). In LSA, the accuracy of word association is gradual. A word is not absolutely defined, as word association increases and decreases according to the provided corpus. This measurement is the cosine.

The cosine is calculated between the vectors of two words in the semantic space. The calculation could be a dot product or Euclidean distance depending on the application and assessment needs. The similarity of two terms is measured by this, and the similarity of two passages is the sum or average of these numbers for each of the words in the passages.

LSA is a subjective practice, linking words with other terms and assigning vectors based on their likeness and relevance to each other based on a series of predetermined relationships. However, the use of the algorithm keeps the practice unbiased and reliable. As long as the system maintains its integrity, it will continue to output useful data.

Basically, this approach should compare like terms and group them to have the same meaning. For example, an image in the icon library may look like a sailboat. Some may interpret it as being a boat, ship, sailboat, or sail boat as separate words. These may all be able to be classified similarly. LSA also will show other terms that are similar or related to boat if instructed such as marina, sea, or sail.

The University of Colorado at Boulder has created a site equipped with pre-computed semantic spaces, LSA algorithms, and an interface for public use. The site's main feature is a collection of five algorithms that use LSA to output word relations. This technology may be useful for this thesis, as it can group related participant-supplied terms to make the data easier to organize and analyze.

To develop the LSA, ample vocabulary and paragraphs are added to the system using prewritten materials such as newspapers, books, magazines, and journals. The semantic space is determined by which material was provided. A 3-6 grade generic reading space would be developed with children's age-appropriate books. The psychology reading space is developed with college-level psychology textbooks.

When the database is complete, a system is built to allow for input and output. A user will supply a corpus, or any amount of data or textual information for analysis, and select the LSA parameters such as semantic space, number of output terms, whether the data is a text or series of terms, and other parameters specific to the algorithm. The system will generate the terms and data based on the corpus.

Choosing the appropriate semantic space is essential in order to output the appropriate results. For example, a generic reading space may associate the word “life” as having energy or vigor, whereas the “Small Heart” reading space, comprised of medical journals and texts relating to heart anatomy and physiology, might interpret “life” only as being alive. The generic reading space is divided into five age groups: up to 3rd grade, up to 6th grade, up to 9th grade, up to 12th grade, and up to 1st year college. This, too, is important to select the appropriate group. A child may interpret the word “ball” to be a toy, whereas an older observer may associate the word “ball” to describe any spherical object or the act of making something into a ball.

For the purposes of this thesis, the “General Reading up to 1st Year College” is ideal semantic reading space, as all participants are required to be at least 18 years of age. This reading space should yield a sample set of participants, most of whom have completed high school. Users can also create custom spaces, but for these purposes, the provided reading space will suffice.

As previously mentioned, the meaning of icons can vary depending on context. The appropriate semantic space should match the icon’s intended use. Since these icons are open for general interpretation and not specific to any one field or discipline, the generic reading space is a suitable choice.

The site is equipped with five algorithms that analyze the provided corpora: Near Neighbors, Matrix, One-to-Many, Sentence, and Pairwise. Each algorithm generates an output necessary for a particular analysis. Choosing the algorithm to use depends on the type of input and suspected output. The Near Neighbors algorithm returns a list of terms similar to the provided terms and is ideal when using single terms and words. The Matrix comparison shows similarities between sets of texts and works well for many words. Sentence Comparison takes textual input and finds the cosine comparison between adjacent texts and is ideal for calculating the coherence and flow of writing. One-to-Many compares one sentence or text against several others and acts as an aid for vocabulary testing and essay grading. Last, the Pairwise comparison reveals the cosines between given texts, similar to the Near Neighbors but using sentences instead of individual words.

For the purposes of this thesis, the Near Neighbors analysis is ideal. This takes many terms as input and links them to other words that are related.

In order to use the site properly, it is advised that at least 50 terms are input. For best results, the corpus should be comprised of at least 300 terms, so having at least near 300 participants would be ideal for this experiment. Each participant may supply more than one term, so the number of terms is expected to greatly exceed the number of participants.

For demonstration purposes, the word "sun" was entered into Colorado's Near Neighbors algorithm and requested ten terms that would generate with a topic space of General Reading up to First Year College (300 Factors). Table 1 shows the results.

LSA Similarity	Term
0.96	sun
0.61	telkes
0.59	revolves
0.56	solar
0.55	corona
0.55	equinox
0.54	Prominences
0.52	billionth
0.52	365
0.51	perihelion

Table 1 – Example of Latent Semantic Analysis Output Using "Sun"

This table shows how LSA, when given the word "sun," will report words that relate to "sun" in a general corpus and assign each of them a similarity score, where 0 is the lowest and 1 is the highest. The "LSA Similarity" column shows the coefficients of each term. The "Term" column is the resultant word from the input "sun."

The first output term describes how the word "sun" relates to itself. Predictably, the similarity is quite high. The second term, surprisingly, is "telkes." This term probably refers to Marie Telkes, a Hungarian scientist from the early 1900s famous for her work with solar power. Most likely, one would see "telkes" and think "sun," not likely the other way around. "Revolves" is commonly associated with the sun as it describes the suns movement. The suffix "s" indicates its most common use when with the word 'sun." "Solar" is an adjective meaning '"of the sun," so it is expected that these terms are related. Both "prominence" and "corona" are words relating to the sun's features. "Equinox" is also a common association, as it describes the sun's position as

directly above the earth's equator. "Perihelion" is the position where a planet in orbit is closest to the sun. "Billionth" can refer to many properties relating to the sun. The number 365 is most commonly used to describe the average number of earth's rotations before completely orbiting the sun once, or in other words, the number of days in a year. Expanding this list will reveal several other words that are not as closely associated with the word "sun." According to this database and algorithm, these are the terms selected that most closely associate with the term provided.

This may be a suitable tool for analyzing the data generated from this thesis. Since the data provided will be textual, LSA can check all terms and compare them against a corpus, generating a cosine relevance value for each. The top 10 words will most likely involve words submitted by the users but may also show other relevant words based on the input's relevance to the corpus. If the input includes the word "ball" and "play," the system might return the word "child," which may also relate to the icon. Some analyses will use this tool.

Direct Manipulation

Direct manipulation is a term coined by Ben Shneiderman describing the concept of being able to act on a system without knowledge of background processes (Hutchins, Hollan, & Norman, 1986, pp. 87-124). Basically, when one drives a car, placing the foot on the brake or gas pedal causes numerous reactions inside the vehicle. The driver does not need to know these processes in detail. All that is necessary is when the driver presses on a certain lever with a force; the car either increases or decreases its velocity. Contrarily, indirect manipulation would constitute having to modify the interworking of the system before being able to change the state of the system.

In computers, direct manipulation is usually possible through an interface. A software system such as Adobe Illustrator (Adobe, 2005), allows a user to change what is on screen using predefined tools and functions. For example, a user's goal is to draw a scene. Without direct manipulation, the user will need to define the color of each pixel by entering the data into a matrix that the computer can understand. If using vectors, the artist must define the points on a line, create a formula to draw a sinusoidal curve, or apply the appropriate summations to illustrate an aesthetically sound Bézier camber. Such a cumbersome approach is not desirable for most users. A direct manipulation interface spares the user from developing complex mathematical formulas and tedious data entry, which may usually result in an error. One incorrect number or faulty operand may cause the system to crash or produce an undesirable outcome. With a direct manipulation tool such as Illustrator, the user may draw lines like an artist would on a canvas.

Dragging the cursor can create the perfect formulas to depict the shape in the same amount of time it would take to make a similar mark on paper. A user may also use tools in the software to draw shapes, lines, and irregular figures quickly and efficiently. Manipulation tools allow the user to easily modify a shape or create perfect replicas quickly. Some aspects of the program allow for an indirect alternative if it is more desirable to the user. For example, choosing a color in Illustrator is simple. One click on the palette will fill a shape with a solid color. However, if the user requires a particular hue, the option to insert the hexadecimal equivalent is available. Direct manipulation matches the way one naturally thinks about a problem, eliminating the abstract computational and analytical steps. It is much more intuitive to draw a line by placing points on a grid instead of typing those points numerically into a system.

Direct manipulation has many benefits (Hutchins, Hollan, & Norman, 1986, pp. 87-124). Beginners can learn the system quickly and usually get enough information through a tutorial or demonstration. Users can quickly and efficiently complete their tasks, and experts may even able to define new processes and procedures for later use. Those who do not use the system regularly will be able to retain common practices the next time the tool is used. Abstract concepts are not easily memorized. Fewer errors are committed. When working with root-level concepts, such as in a programming language, the user is bound to make more errors than when the system is created using software that prescripts these functions for the user. This yields fewer error messages. Instant feedback allows users to see their progress and monitor whether the actions performed are working toward the user's goal. Also, users are less anxious, as the system is more intuitive and comprehensible, and mistakes are easily reversible.

Of course, there are some hindrances to the direct manipulation approach (Hutchins, Hollan, & Norman, 1986, pp. 87-124). There are tradeoffs. When one simplifies the interactivity by creating prebuilt features, the background processes become hidden. This usually limits the system's capabilities. This exchange is usually worth the added limitations, as it provides an easier mode of interaction. Some direct manipulation interfaces are inexact, sometimes have difficulty handling the user's specific guidelines, and sometimes overgeneralize the user's needs. Sometimes users are given the task to control the exactitude and perfection of a system, something that may be best left to the machine.

According to Shneiderman, direct manipulation must be capable of three actions. The first is that the entity being modified should constantly be visible (Hutchins, Hollan, & Norman, 1986, pp. 87-124). Second, interaction should be as easy as clicking a labeled button instead of modifying complex syntax or working in any root-level environment. The last requirement is that there should be instant feedback. The results of an action should be immediately apparent, and the

system should allow the user to easily undo any change. These rules are similar to Nielsen's Ten Usability Heuristics, previously discussed (Nielsen, 2005).

One of the first instances of direct manipulation in computer software was the Sketchpad application designed by Sutherland (Hutchins, Hollan, & Norman, 1986, pp. 87-124). His aim was to make it efficient for a designer to draw lines. He was one of the first to devise such an idea, harnessing the power of graphical user interfaces. His approach was a metaphor perceiving the display as a canvas or paper sheets and using a pointing device as a pen, showing constraints, and graphically representing abstract concepts. His idea took about 20 years to have a significant impact on the computing industry. His software required substantial processing power and was too costly to catch on too quickly. His work is reflected in many modern art and computer-aided design programs.

Computer art used to be generated in this manner. However, Larry Tesler discovered the importance of participatory design while at Stanford (Tesler, 1981). He devised a way to print instruction cards for stunts at football games, hiring art students to design the polygon graphics on each card. The students had to produce the code, but found it unintuitive and difficult, causing many to quit. Tesler discovered that artists had trouble using the language. He considered that artists may think differently from programmers and realized that if he was to design an art tool, it would have to cater to the artist's thought process. The user expects the software to behave a certain way, so developers should accommodate the application to these anticipations. Tesler spent three years refining the language so that it was simple and intuitive enough for the art students to use.

The best approach to direct manipulation is often found through user feedback (Tesler, 1981). Preliminary usability tests gave researchers an idea of how to develop software to suit the user. Trends in user feedback typically indicate the best way to develop a system. When Xerox PARC was working on the NLS (oN-Line System), Larry Tesler wanted to develop a system that a user could learn in under one day. Many developers at PARC praised NLS for its ease of use. Tesler was skeptical, claiming he could make something even easier and quicker to learn and master. He called his program Mini Mouse, as the user needed a mouse with only one button to operate it. Before developing the product, Tesler performed a blank screen usability test. He sat a user who was not familiar with the emerging NLS in front of a blank screen and asked her how she would interact with the screen if she wanted to perform certain tasks. Her simple and intuitive answers amazed Tesler. He developed a prototype using Smalltalk. The system was so easy to use that people unfamiliar with any digital text editing system could learn it in five minutes compared to a week with the NLS. PARC had discouraged usability testing, as it was usually an

expensive procedure. Tesler's approach cost no more than a few minutes of the participant's time, and he was able to develop a system that was much easier to learn than the current product. Users found the system enjoyable as well as intuitive. Alan Kay, a PARC employee, comments that, "I ran the camera for the movies we took and remember [the user's] delight and enjoyment" (Kay, 2006, p.22). An engaging user experience makes for a better product. With direct manipulation, this basic editing program could turn the daunting task of writing into an entertaining experience.

Tim Mott and Larry Tesler eventually started working together (Tesler, 1981). Jointly, they expanded on Tesler's Mini Mouse system, calling it Miki Mouse. The standard mouse had three buttons, but the duo wanted to keep the application simple enough to require only one. This would make it possible for the application to work with other devices such as tablets and light pens, which are only capable of one-button clicks. They devised double-clicking, which allowed users to perform different actions using the same button. A single click on a word would place the cursor between letters, and a double click would highlight the word. Tesler implemented this because he believed that users could double-click easier and faster than they could click and drag over a word. Usability tests proved this assumption accurate. It took, on average, roughly 2.6 seconds for a user to highlight a word by clicking and dragging, but only .5 to highlight it using a double-click (Tesler, 1981). This allowed the developers to preserve one-button functionality and offer more control over the interface. To make interaction easier, they sought a way to rearrange text existing in the document. After trying different techniques and conducting usability tests, they devised several keystroke commands. Mott and Tesler constructed keyboard commands to undo a previous action, delete a selected series of words or characters, copy and paste text, and cut and paste text. They hoped to make editing easier for the writer. Similar to the desktop metaphor, this idea also helped the user to understand an abstract concept by relating it to the familiar concept of scrapbooking. Part of the reason for the success of Xerox PARC and Apple is that they considered the users' interest when developing their products. Some solutions to product development were so effective that they became the foundation for more modern applications, setting a new computing paradigm in direct manipulation. These examples prove the effectiveness of designing for the user.

Distance and Engagement

In direct manipulation, there are two aspects that describe the impression of directness: distance and engagement (Hutchins, Hollan, & Norman, 1986, pp. 87-124). Distance describes a figurative space between one's thoughts and cognitive processes and the physical requirements of a system. A "short" distance means that understanding the system is simple and effortless. The

user's thoughts are easily translated into the physical actions necessary to operate the system. The output is in an understandable form and allows the user to easily guide progress to a goal. The issue here is to minimize the effort, be it cognitive, physical, or any other sort. Distance refers to the relationship between the goals of the user and the way the user can reach that goal using the interface.

The qualitative measure of a feeling of directly interacting with elements is engagement (Hutchins, Hollan, & Norman, 1986, pp. 87-124). There are two metaphors used to describe interaction techniques. The first is a conversation metaphor. Here the system is interacted through language. The user and system have a "conversation" about an assumed world. In this technique, the interface is an intermediary between the user and world. Basically, a user interacts with an interface, which changes the state of a perceived world. An example of this could be a graphing calculator, which requires that a user insert formulas into one area so that they can be graphically represented in another. Programming languages work similarly. A scripter writes code to dictate which objects show on screen and which actions respond to specific inputs. The writer will not know the exact output of the code until the script is run. The second approach is a model world metaphor. The interface is the world upon which the user acts, and actions usually have clear and immediate feedback. There is no intermediary. This allows users to interact with the objects and elements in the world, supporting direct engagement. Many modern applications use this method, as it is more intuitive, efficient, and natural than the latter. As previously noted, programmers develop applications by writing code. New software such as Adobe Dreamweaver, allows beginner web programmers to construct sites using an interface. The application lays out the elements of a website. The user c easily modify them by selecting certain colors or clicking and dragging to manipulate an element. This spares the user from using the code until more advanced functionality is needed. The interface offers a WYSIWIG (what you see is what you get) approach, so the user develops the page much like arranging images and text on a canvas.

The distance between the goals of the user and descriptions of the system are known as the gulf of execution and the gulf of evaluation (Hutchins, Hollan, & Norman, 1986, pp. 87-124). The former is reduced by making the interface more intuitive for the user. Therefore, a system should mesh with a user's mental model of how the system should work. The latter is reduced by making the output sensible and providing feedback that is easily visible and understandable. Immediately showing the result of all actions will make for a more evaluable system. The closer the distance, the less cognitive effort is required to operate the system. The distance of these gulfs can be subjectively calculated by measuring how much effort it takes to use the system. Working with a system should feel natural. The users should feel as though they are interacting directly with the elements, not a computer, not a machine, not formulas, or functions.

Interfaces use their own languages (Hutchins, Hollan, & Norman, 1986, pp. 87-124). Some of these do not fit the typical definition of language, but it is the means of communicating with the system or the system's way of communicating with the user. Turning a steering wheel or clicking buttons are some examples of input languages. Each instructs the system to do something in particular. The output language may not match the language used for input. A car may change direction, an application may run a process, or a light may turn on. All these are the results of human input.

Direct engagement occurs when a user has control of the elements on a platform without the need of an intermediary (Hutchins, Hollan, & Norman, 1986, pp. 87-124). At the very least, there are a few attributes required by a direct engagement system. The gulfs of execution and evaluation must be as short as possible. Input and output expression should be related to each other, and later inputs should be based on previous outputs. That way it seems as though the system is working toward the user's specific goal. The system should have instantaneous feedback, unless it is necessary to delay it to improve the interface. The interface should not be obtrusive. The user should be able to work with the system without necessarily being aware of its existence. If it is noticed, then it should be a tool that aids in engagement with the elements and not interfere with it.

Literature Review Conclusion

In summary, numerous factors can affect one's perception of a shape. Iconography is used to communicate a message in a clear and concise manner, and the interpretation is ideally unaffected by demographic profiles such as language and gender.

When analyzing the data in this thesis, it was imperative to reflect on the details presented in this section. Knowing more about how an icon communicates expanded the interpretation of the experimental results and will offer more insight for the best practices in icon development for future designs. This information also guided the experimental procedure so that the thesis generated the most relevant data and minimized the variables. This knowledge also assisted in data analysis, as one must understand the factors to interpret the data properly.

In reference to Louis Sullivan's quote in the beginning of the literature review (Sullivan, 1901/1970, pp.36-45), art can, in fact, serve functional purposes that can improve daily life, make industry more efficient, and advance the usability of everyday tools.

Introduction

An icon is a communication device; it conveys meaning in a concise manner. Icons are used throughout the world in almost all venues such as roads, buildings, packages, engineering, and computer systems. Designers of icons expect the symbol to express a certain message, an action such as “stop,” “grow,” or “move,” or a location such as “Men’s Restroom”, or “files.” Icons replace words that may be too cumbersome, large, or convoluted to be effective. Some are language specific and may only communicate to a particular audience. Many icons are designed to be understood across cultures such as those seen on shipping boxes. The one symbol replaces the need for multiple international languages on the box.

Icons are potentially an ideal means for communication. However, they are often ambiguous in meaning. One may arrive at an incorrect conclusion about what an icon represents. Icons are designed to be intuitive, but often they take effort and learning to understand. Many road signs may not be clear until the driver studies them and learns their intended meanings. An effective icon will be understandable quickly and upon introduction. However, there are many factors that make an icon ideal.

In this thesis, the intuitiveness of a group of icons designed intentionally for the purposes of this experiment by the investigator was tested. This study investigated demographic information such as gender, age range, technical experience, and country of residence, and determined if and how these affected interpretation.

Icons should be recognizable to all. Since this is not always attainable, it is important to know which icons to use in certain settings and with a targeted demographic. Variables such as icon color may affect one’s interpretation. However, it is not only the icon that affects the interpretation, but also one’s personal experience. What may look like a tree to a child may be seen by adults as a key. The icon is effective but means two things to different people. In order to have a properly functioning icon, these factors must be considered. This study is expected to reveal more about how people perceive icons according to the variables.

Problem Statement

This thesis investigated means to objectively measure the clarity of a visual symbol. The goal was to establish an objective assessment of the symbol-meaning relationship and then compare how a populace of varied demographics determines the influence of color (black, red, blue, orange, and green) on icon meaning.

Symbols such as icons used in computer interfaces are necessary, useful tools for presenting information in an efficient and effective manner. Icons are often misinterpreted, rendering them ineffective. A person's gender, age, residence, and technical background may affect interpretation of the perceived icon meaning. Understanding how people of varied demographic profiles interpret an image will give more insight to professionals who employ that icon in their work. Characteristics of a graphical icon such as the color may also affect one's interpretation. This study focused on correlations between the populace's interpretations and the icon's color. To collect user-specified labels, users took a web-based survey containing a library of 50 images of varied colors. Each user was asked to submit personal demographic data for statistical analysis.

Hypothesis

One's age, gender, technical experience, and country of origin may affect the observer's interpretation of an icon. The color of the figure may also change the interpretation. This thesis tested the hypothesis that an icon's interpretation is dependent on the observer's demographic profile and color of the image.

Variables

A library of icons with individual predefined colors was used in the experiment. The same images were presented to all users. Demographic profiles, including age range, gender, country where the user has spent the most time, and technical experience, were collected from all who participated. The icons were designed for this experiment and colors were chosen for popularity, diversity, and visibility. The response set was dependent on the icon being viewed, the color of the image, and the participant's demographic profile.

- Independent Variables:
  - Color
    - Black
    - Red
    - Green
    - Blue
    - Orange
  - Icons (50 images)
  - Demographics
    - Gender
    - Age
    - Country where user has spent the most time
    - Technical Experience
- Dependent Variables:
  - Response Sets

Control

A random order of icon presentation reduced biases related to order.

Since the colors of the icons varied, black was considered to be the control. In this case, a black figure with a white background was labeled as having no color. The variables were the colored icons. All images had a white background.

Methodology and Experimental Design

Experimental Design

This test is best described as a post-test only control group design (Campbell & Stanley, 1963, pp. 25-27). Basically, this experiment involved taking a random population and testing some with the control and some with the experimental. Visually, the experiment looks like this:

R X O_1

R O_2

R represents a random population, X represents the exposure of a group to a particular variable, and O represents an observation of a particular measurement (Campbell & Stanley, 1963, p. 6). Each icon in the library of 50 was its own experiment, and each participant who viewed the particular image was randomly placed in either the experimental or control group. There was a 1 out of 5 chance the participant would be the control, as this experiment tested for four colors and black and white, where the latter is the control. Expanded, the visualization of the experiment can look like this:

R X_1 O_1 : Orange

R X_2 O_2 : Red

R X_3 O_3 : Green

R X_4 O_4 : Blue

R O_5 : Black

This type of test was ideal for this experiment. While pretests are usually encouraged for experiments and offer more credence to the variables, using them in this experiment may have biased the user's results (Campbell & Stanley, 1963, pp. 25-27). An instance of pretesting could involve showing the user a black icon, then later the same icon in a different color. However, the first impression of the icon could skew the interpretation of the colored icon.

The purpose of this experiment was to analyze how people perceive certain iconic representations. Participants used a web interface that asked them to provide text descriptions about what they thought an icon represented. This yielded qualitative data for analysis. If the icon were a tree, the participant may have written “tree,” “plant,” “vegetation,” or even “leaf.” Participants could type any description they wished. After entering the text, they pressed the “submit” button, which entered the input into a database, linking that answer to the user and the icon. The person was then presented with a different icon, and the process restarted. All responses were modified and grouped to simplify analysis.

To eliminate variables, the website intentionally does not provide context. The context in which an icon appears can dramatically affect icon interpretation. In this experiment, context is not considered.

Analysis of Correlations and Relationships

The analysis of the icons required numerous steps. First, data collected needed pre-processing for analysis. The relevant terms needed sorting simplification, making analysis simpler. Graphs showed the number of each response per icon. A Multinomial Logit Analysis model, run in SAS and Minitab, generated the necessary graphs to show the response results and assessed the comparisons between collected values. An analysis showed the correlations between each of the independent variables (the given icon collection and demographics) and color. This experiment was expected to show how intuitive each symbol was to an observer of a specific demographic profile by comparing a response to other participant responses.

Materials

Website

Together with software such as a text editor like Adobe Dreamweaver and image and graphic producers such as Adobe Illustrator and Photoshop, a computer was a necessary tool for building the online site. Almost all website code and design was produced by the investigator. The site needed to be aesthetically pleasing and user friendly but not distracting and offer a way to present the icons and effectively collect user-provided data. Web server space from an external hosting provider was used. The host supported PHP5 and allowed for PhpMyAdmin. An internet connection, plain text editor, and FTP client were necessary to develop and upload files efficiently. A web browser was necessary to test and manage the application when building it.

The site resided on the domain www.iconstudy.com. A full description of the development process is found in Appendix A and source code in Appendix B.

This procedure required remote participants who had access to a computer and the internet. They needed a computer that supported Firefox 1.0 and up and Internet Explorer 6.0 and up. The screen resolution needed to be a minimum of 800px x 600px. Clients used their own computers to complete the surveys.

Icons

A series of 50 icons depicting abstract shapes were created by the investigator using vectors in Adobe Illustrator Creative Suite 2. Some were reproductions of icons used in certain venues, and others were original compositions. A list of all icons and categories can be found in Appendix A. Vector images are necessary for such an experiment because they do not compromise quality for size.

Icons come in all shapes, sizes, and colors and, therefore, must take into consideration the many factors that could change the icon's appearance. All icons should fit in a square. These images would not be phonograms and contain no text or obvious alphanumerics. Using American characters would introduce a new variable and, therefore, were not used.

The image bank contained an assortment of common and unusual shapes, as well as replicas of popular symbols and icons that are common in certain venues.

RIT Instructional Review Board Approval

Executing a study on human participants at the Rochester Institute of Technology required approval by the Instructional Review Board. RIT enforces the policies of ethical and safe research. Therefore, a series of forms were completed before research was permitted. All important communications with the IRB are located in Appendix F.

Gathering Demographic Information

The survey collected demographic information from participants so that the data would have more meaning. This data was used to find correlations between interpretation and demographic, if necessary. Before taking the survey, the user was presented with five questions: gender, age, technical experience, country where the participant has lived the longest, and email address. The

user was allowed to refuse providing an email, but it was required if they wished to win the incentive. All emails were kept confidential and were not published.

The survey form can be found in Appendix E.

The gender question was a radio button with the options of either “male” or “female.” Usually males and females have different perceptions of what icons mean, probably due to varying life experiences or differences in cognitive processes. There may have been distinct differences between the interpretations of certain icons.

Age was an important variable in this study and was considered in the data. This field was a radio button with ranges of ages of 18 to 30, 31 to 45, 46 to 60, and over 60. Since people are usually reluctant to give out age on a survey, the ranges will give them a chance to be more discreet about the information and increase their willingness to provide it. Typically, observers of varying age groups have different experiences and cognitive abilities that may create discrepancies between the data sets.

Technical experience can change one’s perception of the online survey and the icons presented. Computer savvy people may have more experience with many common icons than the average user, as software usually employs libraries of icons to improve interface quality. This field was a series of seven radio points on a 1-7 Lickert scale, where 1 is low and 7 is high, which allowed the participant to make a subjective assessment of one’s own technical expertise (Brace, 2004, pp. 86-89).

Lastly, the users were required to provide the country where they have spent the majority of their lives. Since anyone in the world could access this survey and participate, collecting this information allowed for grouping and sorting for analysis. The user was shown a dropdown menu with several country names. This information may have revealed correlations in culturally dependant observations. Some icons and symbols may have had a different meaning in certain countries than they do in America. Multicultural experiences also added more diversity to the data.

The email field was not required but recommended. The user was to provide an email if they wished to receive the incentive—a raffle—as this was the means to contact the winner. The email was merely for recordkeeping and perhaps contacting an individual if further personal questioning was necessary. Such a case was unlikely. The email field was a text input box.

Testing for Colorblindness

Since this study involved color, it was essential that all participants were able to see the icons as intended. This study needed to filter out colorblind participants. Simply asking the users if they were colorblind would not guarantee that they answered correctly or even knew if they were colorblind. The survey needed to ask whether the participant had any known colorblindness.

The idea originally proposed was that the initial screener survey would contain a captcha in the style of an Ishihara colorblindness test. A captcha is an image that contains a series of alphanumerics that the user must type in a box. This prevents automated completion of the form and verifies that the user is human. In this case, the captcha would also verify that the user is capable of seeing all colors. The Ishihara test was to be a series of three images composed of dots of varying sizes resembling a colored number inside a circle. The user must identify the correct number inside the circle before taking the survey. However, this method had many variables. Monitor resolution and color would affect the results, so a proper Ishihara test could not be conducted on a screen.

Instead, it was agreed that assessing colorblindness was made as simple as the rest of the questions. The survey asked whether or not the person was colorblind. However, it could not be that simple. The term “colorblindness” could be interpreted to mean total colorblindness, and people who were not sure may just guess. The question was written to ask, “Are you colorblind?” The possible responses were, “No, I am not colorblind,” “Yes, I am in some way colorblind,” and “I am not sure whether or not I am colorblind.” This gave the user the option to answer if they were uncertain. A colorblind individual is someone who is diagnosed with colorblindness of any sort. For colored icons, only the responses of the ones who confidently answered that they were not colorblind would be considered.

Developing the Website

A website allows participants anywhere to take the survey. As a method for obtaining participant information, the website required the visitor to complete the short screener, which gathered demographic profiles. Participants would also have the option to review a statement declaring that all emails would be kept private and not associated with any demographic information or responses.

The program interface was simple. The top of the page contained links to privacy statements and experiment information. The images showed on the screen in a 200px x 200px box. All images

would be resized to fit in this area. Beside them were text input boxes large enough to catch the user's attention. The subject could type a description up to 100 characters to describe the respective icon. The user could submit as many terms as necessary, separating them with semicolons (;). A Submit button was positioned at the end of the form. After the user completed the survey, he or she would be allowed to submit the responses.

After the user completed the screener, they were presented with a series of 50 images, each having a random figure color. Users typed words or phrases that they felt best described that icon. To submit the response, one could either press Enter or click Submit at the end of the form. Pressing Enter twice would advance to the next icon. Users could erase a submission by clicking the "Erase" text adjacent to the term. If the text was appropriate, the page would refresh and the participant would see a new image. The procedure continued until the person decided to stop. For example, if the string was not valid because it contained unusual characters or numbers, the subject would be prompted with the respective error upon submitting. The response would have to be retyped before resubmitting.

This part of the experiment was similar to a survey. Unlike the typical questionnaire, the questions were the images, and they were presented in a random order.

Pilot: Informal Usability Test of System

Before publicizing the website, it was necessary to make sure the test was intuitive and functional to eliminate confusion during the experimental phase. It was not necessary to run a full-scale usability evaluation of the system, as it was simple and small. A quick heuristic evaluation and short accounts of testing informally on willing participants revealed noteworthy problems with the system.

Ideally, a usability test would be an established experiment with a document stating the details and execution of the procedure. This particular test was informal, as this did not require the professional standards, time, or cost for a full-scale, personal usability evaluation.

During development of the system, many revisions were made based on changes in the experimental scope, noticeable avenues for improvement, and feedback from observers and committee members. Originally, the experiment was an image and a text box. Each descriptor in the box must be separated by a semicolon. Some participants said this was too confusing and complicated, so instead the system was developed to handle each input as a separate cell in an

array. However, participants were expected to make typing errors, so an “erase” button was added next to each response as an intuitive way to erase the input.

After developing the system, volunteers were observed while doing a dry run of the experiment. The observations revealed potential usability flaws with the experiment. Participants also offered suggestions to improve the interface or expressed their frustrations with the system. The system was revised.

Observations revealed many means of improving the system. Participants were investing too much time in taking the survey. Originally, it seemed as though there should be fewer icons to interpret. However, the study revealed that participants spent most of their time grabbing the mouse to click the add button, placing the cursor back on the input box, or clicking the button to go to the next icon. To improve the speed, the system was changed to allow the user to add a response by pressing the “enter” or “return” key once or go to the next image by pressing it twice within one second (similar to a double-click of the mouse).

As required by the IRB, users must have the option to opt out of the survey at any time. Worried that some users would simply navigate to a different page or close the browser, a “Quit” button was added to the upper right of the screen. By clicking this button, the survey would end, and the system would write the data the participant provided to the database. This would provide more data at the end of the analysis. Closing the browser before submitting the data at the end would erase all data. Participants who quit the proper way would still have been eligible to win the incentive if an email was provided.

User comments also revealed areas for improvement. They suggested that users should not have to click on the input box to resume typing. The box was already refocusing on the input box upon addition or submission of the response. However, if the user anywhere clicked on the page or pressed the “tab” key (which would advance the user to the next interface on a web form), the focus would no longer be on the input box. Therefore, a JavaScript interval was added to the form to constantly refocus on the input box. If a user were to move away from the box, they would still be able to type in it.

The instructions under the image were unclear to most participants who read them. These were rewritten for conciseness and clarity. A short instruction page was also added so that the users could review the process before taking the survey. However, many users probably skipped the instructions. Regardless, the interface was intuitive enough for participants to manage.

Improving the interface and fixing system caveats hopefully encouraged users to take and complete the survey and produce more accurate results. An easy-to-use site allows participants to focus on the tasks instead of the interaction with the survey. Fewer distractions yield fewer variables.

Recruiting

The survey was advertised on public websites and in places that contain a populace of varying demographics such as colleges. Since demographic profiles were collected, the data was controlled to ensure sufficient variance. If there was a bias in the data collected, such as 90% of the participants being recorded as male, appropriate measures could be taken to reduce misinformation.

Since this phase of the experiment was to gather quantifiable data from quantifiable sources, many participants were necessary. Ideally, over 1,000 people should have participated. Two hundred ninety-nine (299) people participated in this experiment, which was more than sufficient for the data needed in this thesis. Advertisement of the survey's website was presented on message boards, weblogs, and other websites where the experiment could gain publicity. Fliers posted at RIT informed the public about the website, along with the incentive. Some faculty members at RIT advertised the experiment to their students, which proved to be one of the more effective approaches. This author ran advertisements on Facebook's website, www.facebook.com in order to gain more participants (*Facebook*, n.d.). A complete list of advertisement methods is published in Appendix G.

A large sample set yields more accurate data. It will also give more insight to the symbol-meaning relationship for each demographic. The preference was to have participants of each demographic profile comment on the images.

Incentive

In order to increase participation, entrants were offered an incentive for their participation: a prize to five users randomly drawn from the response set. A user was required to complete the experiment and agree to leave their email address before being eligible to win a $15 gift certificate to Barnes and Noble Booksellers.

Winners were selected at random. When a participant completed the survey, the demographic information provided was placed in a table in the database. Information unique to each participant

was placed on a row, and a row number was assigned. An impartial committee member chose 10 numbers from 1 to 299. The participant whose row number matched the chosen number won the incentive.

The first four participants chosen were checked to see if an email has been provided. If it was not provided, an email was sent to them requesting that the participant provide a mailing address by a specific date. Those who did not provide an email could not win, so the participant who matched the next number on the list was checked. If a participant did not reply by the given date, they were no longer eligible to win, and the next participant was chosen and given a later date.

Procedure

After the experiment was properly designed and the survey tool had been tested and functioning properly, the data collection could begin.

1.) Participant Visited Survey Website

To have an effective survey, people needed a reason to participate. The experiment was advertised. An incentive of a $15 Barnes and Noble gift certificate also encouraged people to invest the time.

2.) Participant Completed Screener Survey

All participants completed a short screener survey before taking the actual survey. This determined whether the participant was eligible, discussed the terms for taking the survey, and collected demographic information.

3.) Participant Completed Icon Interpretation Survey

After submitting the screener answers, the user was taken to a page that asked the participant to interpret the given icon, provided that the participant certified that he or she was over 18. All icons were shown once but in random order. Every icon showed in any of the five colors at random. Hence, all icons were seen once, but colors varied. Participants were required to give at least one response to each icon, though they were allowed to provide a virtually limitless quantity. The user could quit at any time by pressing the “quit” button.

4.) Experimenter Collected Data

Upon completion of the 50 icons, the program collected all data, including demographic information, stored it in the database, and excused the user from the survey.

5.) Experimenter Reformatted Responses

After sufficient participation, the data was extracted from the database. The responses were altered so that they contained only names, nouns, verbs, and significant words, unless an insignificant word is the only one provided (such as “in”). The experimenter meticulously changed this data by hand, though organizing the data and running a find and replace or macro made the job more efficient. Spelling was also important. If a word was clearly spelled incorrectly, the experimenter corrected the spelling so it matched the rest of the words. In cases where the word could not be accurately determined, the experimenter left it as it was. Brand names were generalized (i.e., band-aid to bandage) if the experimenter felt this was necessary. All words, unless they were part of a common phrase or name, were placed in their own column. Therefore, “computer system” may have counted as “computer” and “system,” unless it is understood that “computer” was an adjective. Words that were separated but may be one word were concatenated at the

experimenter's discretion. If many participants wrote "snowman," and one wrote "snow man," the experimenter changed it to one word.

6.) Experimenter Modifies Data for Analysis

For this experiment, a response was significant if it totaled a frequency of 10 or more. Most icons yielded many different responses, so only the top 10 were considered for analysis; these were interpretations that most participants agreed were accurate.

7.) Experimenter Analyzed Responses Using Multinomial Logit Procedures

After collecting the data, the user focused on all data from a particular icon number. The lines that contained responses under 10 occurrences were removed. The data was rearranged to properly fit into the provided code for SAS. The program was run with the data to perform the analysis on as many variables as possible. Some demographic types were not able to generate the correct numbers, as data was insufficient.

8.) Experimenter Investigated and Noted Significant Changes and Interesting Findings

The p value generated in SAS using the data showed whether or not the particular comparison was significant. Values under 0.05 were considered significant, but other data in the system may have showed results worthy of discussing.

Data Collection and Analysis

All data were collected and maintained in a MySQL database driven by PhpMyAdmin and attached to the PHP code.

Data Interpretation and Graphing

After being collected and stored in the online MySQL database, the data were exported using a PHP function designed to report the data for a specified icon. The data presented if it matched the icon number provided. To make the data more specific, the PHP function was rewritten to allow icon color input as well as icon number. The program would report the results for the specified icon number and color. Further revision was required. If the data were submitted by a user who did not confidently answer that he or she was not colorblind, the data for colored icons (not black) would be ignored.

Testing Data Interpretation Procedures

The data were placed in the LSA Nearest Neighbors algorithm on the University of Colorado at Boulder's website. This generated interesting responses, but many were bizarre. Since LSA generates a list of related terms to the submitted text within a corpus, the system made irrelevant comparisons. For example, in icon #20, people identified a star-shaped icon as a "star", but the LSA yielded terms such as "rigel," "Sagittarius," and "asterism," terms which, in context, may appear with the word "star," but were not relevant to the icon or most of the responses provided for the particular icon. A complete list of the generated LSA is published in Appendix D. It was predicted that some words would be generated by the algorithm that were not relevant to the initial data. However, too many words were irrelevant to the provided input and did not fit the icon in question. It was necessary to refine the collected data before continuing with LSA or taking a different approach.

The data collected in the experiment is pure, unmodified by experimenters. The user submitted the data through the online form as was presented as the user entered. The data were difficult to analyze in its pure form, as there were alternate representations of the same word, spelling errors, intermediary (insignificant) terms, terms users entered to "pass" on the word, and other terms that could affect the results. In order for the data to have more meaning, be clearer, and easier to analyze, it needed pre-processing.

PhpMyAdmin created a CSV document containing the data to be modified in Microsoft Excel. The plan was to remove all intermediary words, spelling errors, false or non-serious submissions, terms used to pass on an icon (such as “I don’t know” and “no idea”), and try to coordinate names (u-turn, u turn, and uturn should all be uturn, or “don’t turn here” to “no turn”). Best judgment was used when fixing spelling errors and editing word hyphens. Words that were significant should remain, and insignificant words should be removed. In the term “You can sit on this,” remove “you,” “can,” and “on.” However, keep “on” in terms like “place on top of dresser,” as “on” is significant and important to the overall term.

Similar words such as “fast” and “speedy” were kept as they were written and not compounded, as they carry different meanings. Prefixes, suffixes, and different word tenses were also left as they were, as “write,” “wrote,” “written,” and “writes” have different meanings. The word “writing” could mean the verb “to write” or a piece of written work and, therefore, the meaning should not be compromised by using only the root word. Ambiguous words were untouched. Words with obvious typos or spelling errors were changed using best judgment. The resulting information was uploaded as a new table in PhpMyAdmin.

In order to refine the results, the data were separated and parsed using the space as a delimiter. All responses were only one word or hyphenated. This required creating a PHP parser that adds a new word on the next line after the space, and then appended 100000 to the unique id of the user’s demographic information for each new instance of data for processing purposes and to preserve the uniqueness of the values. For easy calculation, the responses for colored icons of the participants who did not confidently state that they were not colorblind were moved over one column and did not count in the calculation. They were not erased in case the data would be of value later. After exporting to Excel, counts for demographic information and number of responses for each color were also conducted. Graphs were made on separate sheets for each icon and color (and one for all colors of each icon).

After the graphs were developed, it was clear that some words were still misspelled. Using subjective assessment, the words that were obviously spelled incorrectly were changed to an appropriate word. Spelling errors that were not as obvious were left unchanged. Counts also affected the decision of word changing. For example, one icon yielded numerous accounts of the word “lightning.” Some participants added the word “lighting,” which is a real word. It was decided that the user intended to write “lightning,” and the words were changed.

The data were exported to Minitab for calculation. After generating graphs based on the number of response occurrences for each icon, it was clear that the data needed further refining. Similar

terms were grouped separately such as in icon #10. “Railroad Tracks,” “Tire Tracks,” and “Tracks” were combined, although they were semantically similar.

A second idea was proposed. Using the same procedure as before, this idea involved taking each response and rewording it to fit a more generic meaning. Words like “bottle,” “container,” and “jug” would all be changed to the most frequently occurring term. It was also proposed that each should instead be changed to the most generic term. The terms would again be graphed and then generalized as needed. This was an extremely meticulous and subjective process. It would require far too many assumptions of what the participant meant semantically when writing the response. For example, homographs like “tire” could hold several meanings. Does it mean to become exhausted or is it the rubber fitting of a wheel? This method would require making an assumption based on the rest of the responses and the opinions of the one changing the data.

The third approach involved removing all unimportant words. Articles, prepositions, conjunctions, pronouns, adjectives, adverbs, and other parts of speech that were not relevant to the overall term were removed, leaving only verbs and nouns. If a term contained two or more significant terms, they were split and written on different lines as if they were separate submissions from the same participant. If a term had no nouns or verbs, it was left as it was or reduced to only the most significant word. If a user submitted the phrase “insert ball in here,” the “in” and “here” would be removed, as they are insignificant, and “insert” and “ball” would be placed on separate lines in the data. The term “insert in here” would be reduced to “insert,” as it is the verb. A term like “in” would be left alone, and “in here” may be changed to either “in” or “here” depending on the frequency of either word in other responses for that icon. This seldom occurred in the data set. If they were approximately equal, the term would be counted as two separate words and neither would be erased. Names and common phrases were left as their own entity. Terms like “compact disc” were left as they were. Next, each word would be simplified to its root word or close form. Words like “writer,” “writing,” “written,” and “writes” would all become “write.” The word “rewrite” would keep the prefix.

This approach proved to be the most logical and accurate way to group the data and seemed to be a sensible, intuitive, and objective way to reformat the terms. After this process, the data was placed in MiniTab. Graphs were generated to show the frequency at which each response occurred. For readability, only terms that occurred more than twice are presented. All graphs are found in Appendix D.

After creating the graphs, it was necessary to determine which responses would be considered for a more thorough analysis. A response with a frequency of 100 would be much more relevant

than one with 2 or 1. Therefore, it was important to determine a cutting point for which responses would and would not be considered.

Initially, an 80-20 correlation was proposed. The top 80% of responses would be considered for final analysis. If the 80% falls within a certain response frequency or series of responses with the same frequency, they, too, would be included in the upper 80%. This caused some issues when determining the numbers. The 80% mark often fell in the frequency of 2, which would include far too many responses. Some icons fell in the frequency of 1, meaning that all responses would be considered for that icon. This was too broad. The ideas for cutting the percent down to either 40-60, or 50-50 were considered, but this could still pose too much variation. The decision was made to see how the data would calculate if only responses with frequencies of 10 or more were considered.

For analysis, the number 1 or 0 was placed in the next cell of each row, indicating whether or not the term should be included in the top 10. Analyzing text in a quantitative manner required advanced statistics. For this purpose, a Multidimensional Linear Regression Analysis was the best tactic.

Therefore, the procedure for modifying the data was as follows:

- Remove all responses for colored icons provided by anyone who did not identify themselves as not being colorblind,
- Remove all non-serious responses (i.e., “I don’t know,” “no idea”).
- Correct spelling errors.
- Combine like names (i.e., “u-turn,” “uturn,” and “u turn” should be “uturn”).
- Remove insignificant terms, leaving only nouns and verbs.
    - If a response does not contain a noun or verb, keep the important words (i.e., “on”).
    - If a response contains an important word that is not a noun or verb, keep it (i.e., in “place on top of dresser,” “place” and “dresser” are important but so is the preposition “on”).
- Separate all submissions into individual words (keep hyphenated terms, names, and phrases as one).
- Combine terms to their root word (i.e., “writing,” “written,” and “wrote” all become “write”).
- Graph responses by frequency for each icon.
- Consider all responses for analysis that occurred 10 times or more.

Analytic Methods

As previously noted, each icon was treated as a separate experiment. Therefore, the data contained in one icon would not affect or compare to others. All analyses took place between response, color, and demographic information.

There are two approaches when analyzing the response sets by comparison: univariate and multivariate. For the purpose of this thesis, the univariate approach was considered, as this offered the most insight to the reasoning people defined for each icon. A multivariate approach would yield complex data that was unnecessary for this phase of analysis. It is also wise to first take a univariate approach to better understand if and where multivariate analysis is needed.

Procedural Category Moderator

In SAS, a function PROC CATMOD (PROCedure CATegory MODerator) can create data comparisons. A data set qualifies as multi-dimensional when there are more than two factors present. This procedure is ideal for analyzing such data and is also capable of analyzing both one- and two-way data structures. Data structures this complex require this analysis to simplify the data into a context that is meaningful (*SAS Work Shop*, n.d.).

PROC CATMOD is capable of analyzing both Linear models and Log-Linear models. The former has well-defined differences between both the dependent and independent variables, whereas Log-Linear models seek association among all variables and do not discriminate between the dependent and independent factors. Even if variables are clearly defined, Log-Linear models may still be the ideal approach. Performing either analysis in PROC CATMOD is doable through least squares procedures or maximum likelihood techniques, the latter of which is ideal for finding comparisons when the cell counts are small (SAS Work Shop, n.d.).

Odds Ratios

The odds ratio concept states a probability between two outcomes. It is based on the Generalized Logit Analyses. The ratio is determined by dividing p_i into p_k, or a particular cell's probability against the last. The logarithm of the odds ratio is a comparison of the selected cell to the last on a logarithmic scale.

This is an ideal means for analysis of the given cells. This will compare one "base" term to all other terms and will generate the odds ratios for each. Given this strategy, the analysis will

produce comparisons for each term to a particular term (*SAS Work Shop*, n.d.). For technical experience, the value will be compared to neighboring values using a coefficient.

Multinomial Logit Models

In statistics, the data being analyzed may not be ordinal. In this case, some of the data, such as the response set, is categorical, meaning it contains text instead of numbers. Therefore, standard statistical analyses may not be feasible tools for measuring such data (Agresti, 1990, pp. 306-317).

A multinomial logit model uses logistic regression by allowing more than two possible values as results. This analysis is useful for data sets where the dependent variable is nominal, not being ordered in any particular way, and contains more than two categories. In this case, we measured the factors that affect a person's interpretation of icons. Ordered logit regression could be used if the data is orderable and has more than two categories. Data such as technical expertise could be ordered in this way, as the data collected used a Lickert scale ranging from 1 to 7, but factors such as colors or responses have no order (Agresti, 1990, pp. 306-317).

The analysis did not perfectly fit the needs of the experiment, but it is certainly a suitable choice for comparing the data. This model assumed that each independent variable is case specific, and the dependent variable could not be predicted perfectly. This method assumed independence of irrelevant alternatives (IIA), which states that alternatives do not affect the results (such as choosing an apple or banana as a snack, the type of apple is irrelevant). In most cases, the person choosing the snack would select between fruits and not necessarily account for a specific type. In the case of icons, the assumption that users would respond to certain icons was based on a variety of factors. In order to account for these factors, the test needed to be run on all possibilities and factors. However, nested logit and multinomial probit follow IIA and may have been suitable alternatives to this model (Agresti, 1990, pp. 306-317).

Analysis Overview

Two programs were necessary for analysis. Minitab calculated and held the data before and after analysis, and a custom-developed program for SAS ran the calculations.

Using Multidimensional Linear Regression Models, each response, color, and piece of demographic information was compared to each other, typically using the most frequently occurring data or the most significant as the base. Every datum was compared to others of its

kind. For colors, black was compared to other colors. It was the base, since it was the control. Doing this generated the necessary data needed to determine the likelihood that one would use particular responses across varying colors. For example, an analysis would show that if the color of an icon is blue instead of black, someone is three times more likely to say the icon represents X than Y.

This analysis applies to all data sets such as gender, age range, technical expertise, and country of residence. Each group could compare to the other so that the likelihood of changing responses based on demographic information could cross-reference. It was possible to deduce that, if one is female, they were so much more likely to say an icon appears one way than if that person was male. In the analysis, either male or female could have been used as the base, as there is no difference in the observation if there are only two possibilities.

This analysis showed how colors of icons and varying demographic information affected the response the participant provided. It also predicted what future outcomes would be.

Traffic Analysis

In order to test the effectiveness of advertisements, it was essential to monitor site traffic. Google Analytics, a tool used for monitoring site traffic, was implemented. This showed statistics such as how many people visited, where visitors resided, and when they entered the site.

Tuesday, June 9, 2009	5
Wednesday, June 10, 2009	3
Thursday, June 11, 2009	5
Friday, June 12, 2009	7
Saturday, June 13, 2009	6
Sunday, June 14, 2009	3
Monday, June 15, 2009	4
Tuesday, June 16, 2009	10
Wednesday, June 17, 2009	31
Thursday, June 18, 2009	66
Friday, June 19, 2009	25
Saturday, June 20, 2009	25
Sunday, June 21, 2009	46
Monday, June 22, 2009	158
Tuesday, June 23, 2009	51

Wednesday, June 24, 2009	18
Thursday, June 25, 2009	17
Friday, June 26, 2009	11
Saturday, June 27, 2009	24
Sunday, June 28, 2009	8
Monday, June 29, 2009	4
Tuesday, June 30, 2009	7
Wednesday, July 1, 2009	3
Thursday, July 2, 2009	13
Friday, July 3, 2009	7

Table 2 – Google Analytics Visits

This table shows the number of visits to iconstuy.com over a series of days. The 'date' column represents the day, and 'hits' shows the number of visits to the site.

After the email was sent from the IT department asking students to visit the site, there was a noticeable increase in site traffic. That day, over 100 people visited the site. Of course, not as many completed the survey. The next day, fewer people visited the site but still more than usual. This showed that the email was effective.

Facebook had a method for analyzing advertisement activity. The ad manager showed the CPM (cost per thousand impressions) and CPC (cost per click) for each advertisement. This tool was helpful in showing the effectiveness of each ad and monitoring how many people visited the site through the clickable advertisement.

Results and Calculations

The experiment included 299 participants and after separating responses to simplified answers yielded 33,082 responses. A complete list of graphs for each icon can be found in Appendix D.

Gender	Count	Percent
Female	130	43.48%
Male	169	56.52%

Table 3 – Gender

This table shows the number of participants of each gender who took the survey. In the table, "gender" denotes the sex of the participant, "count" is the number of participants, and "percent" is the percent of each count against the total.

Level	Count	Percent
1 – Very Experienced	93	31.10
2	69	23.08
3	63	21.07
4 – Some Experience	52	17.39
5	10	3.34
6	4	1.34
7 – No Experience	8	2.68

Table 4 - Technical Experience

This table shows the number of participants at each level of expertise. This Lickert scale ranges from 7 (having no experience) to 1 (being very experienced). In the table, "level" denotes the subjective assessment of one's own technical experience, "count" is the number of participants, and "percent" is the percent of each count against the total.

Country	Count	Percent
USA	285	95.32
India	7	2.34
Canada	2	0.67
China	1	0.33
Ecuador	1	0.33
Dominican Republic	1	0.33
Kazakhstan	1	0.33
Ukraine	1	0.33

Table 5 - Country

This table shows the number of participants from each country. Most participants were from the USA. In the table, "country" denotes the name of the country in which the participant has resided the longest, "count" is the number of participants, and "percent" is the percent of each count against the total.

Age Range	Count	Percent
18 to 36	179	59.87
31 to 45	59	19.73
46 to 60	53	17.73
60 and over	8	2.68

Table 6 - Age Range

This table shows the number of participants for each age range. The larger population is the younger age groups. In the table, "age range" denotes the relative age of the participant, "count" is the number of participants, and "percent" is the percent of each count against the total.

Colorblind	Count	Percent
Yes	10	33.44
No	285	95.32
Don't Know	4	1.34

Table 7 – Colorblindness

This table shows the number of participants who claimed each level of colorblindness. Very few claimed to be colorblind or were not sure if they were or were not. In the table, "colorblind" denotes whether the participant is able to see all colors, "count" is the number of participants, and "percent" is the percent of each count against the total.

Color	Count	Percent
1 - Black	6,597	19.94
2 - Red	6,511	19.68
3 - Green	6,641	20.07
4 - Blue	6,644	20.08
5 - Orange	6,689	20.22

Table 8 – Icon Color

This table shows the number of responses for each icon color after analysis. Based on the counts, each icon has almost the same number of responses. In the table, "color" denotes the icon's color and assigned number, "count" is the number of participants, and "percent" is the percent of each count against the total.

Statistical Analysis

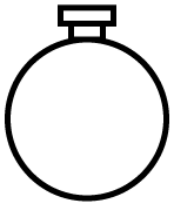


Figure 14 – Icon #00

Figure 15 – Icon #16

Figure 16 – Icon #25

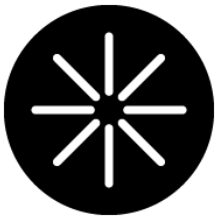
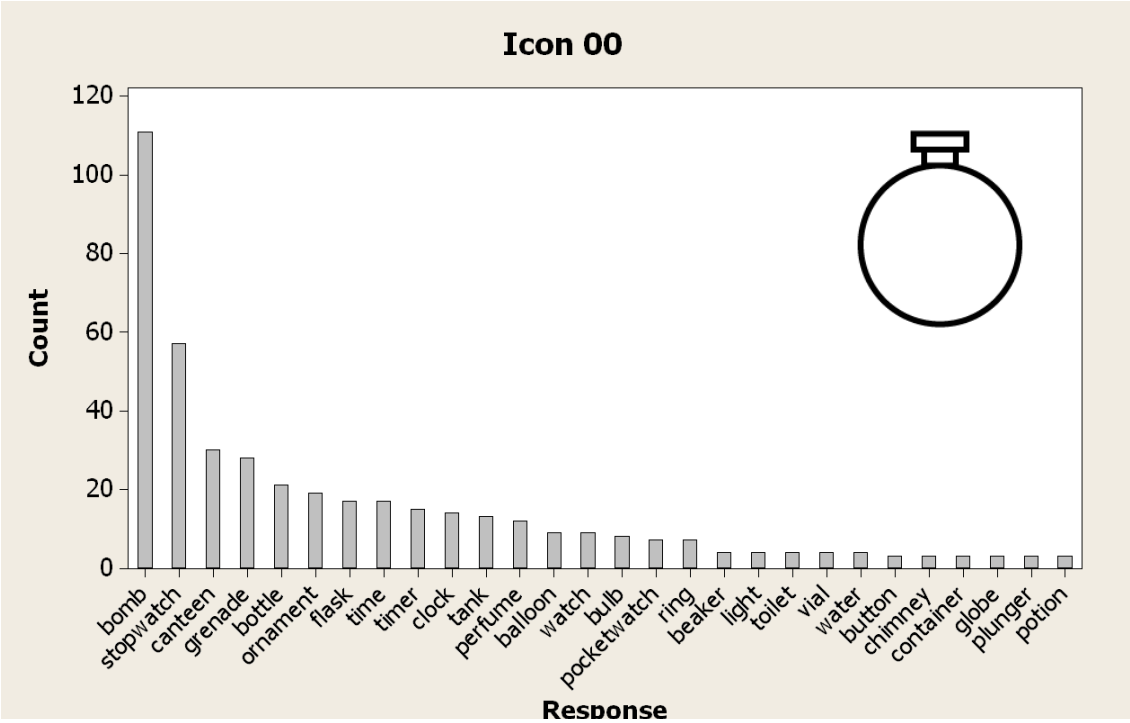


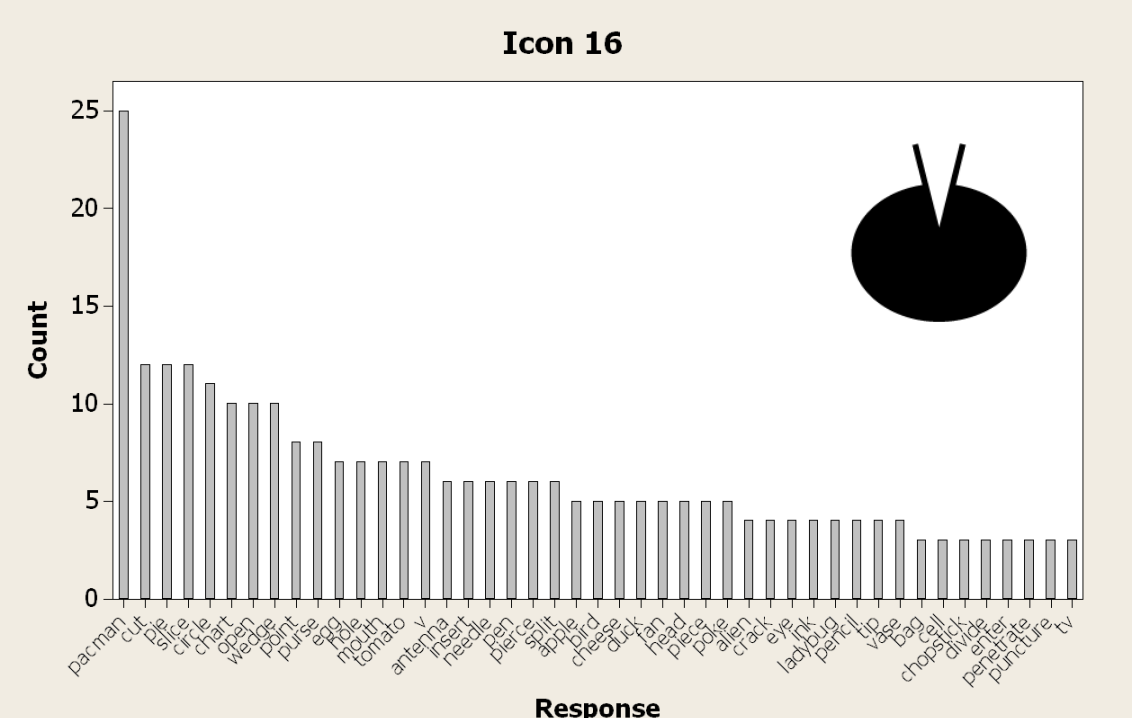
Figure 17 – Icon #46

Icons #00, #16, #25, and #46 were the images chosen for further analysis. This was based on the preliminary analysis of the responses they generated. Each icon was presented in black, red, blue, green, and orange.



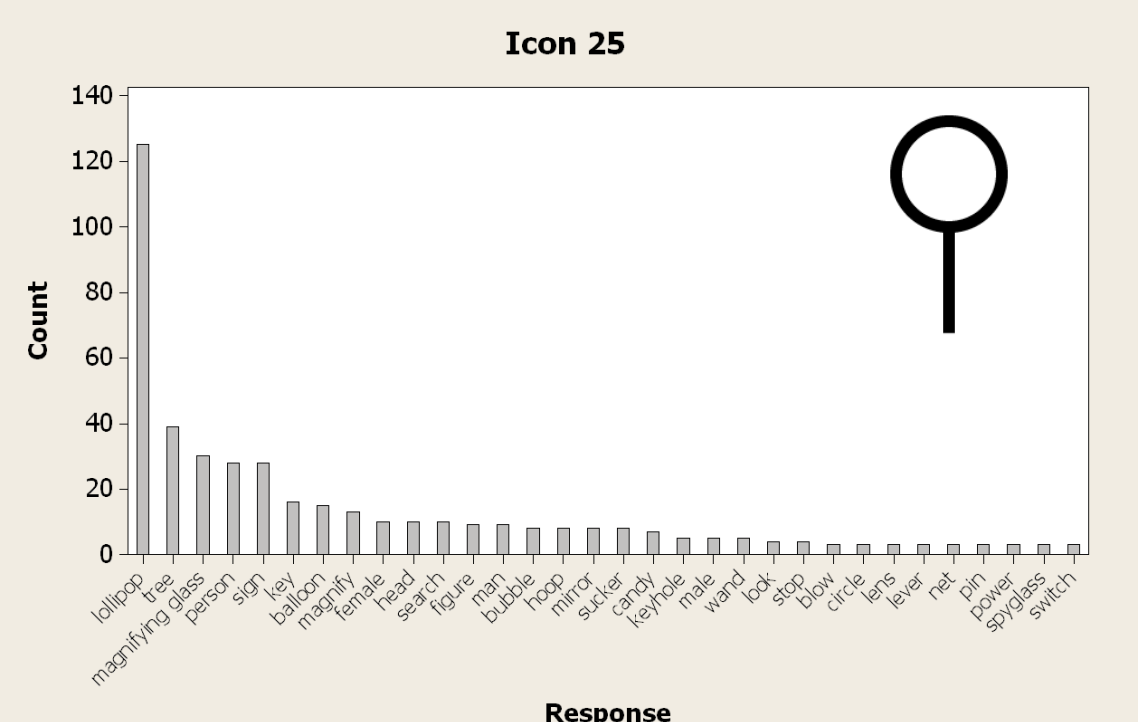
Graph 1 – Response Frequencies for Icon #00

This graph shows the response frequencies of each term (greater than two) for Icon #00. Only the responses equaling or exceeding a frequency of 10 were considered for analysis. Since "bomb" is the most popular response, it was set as the base.



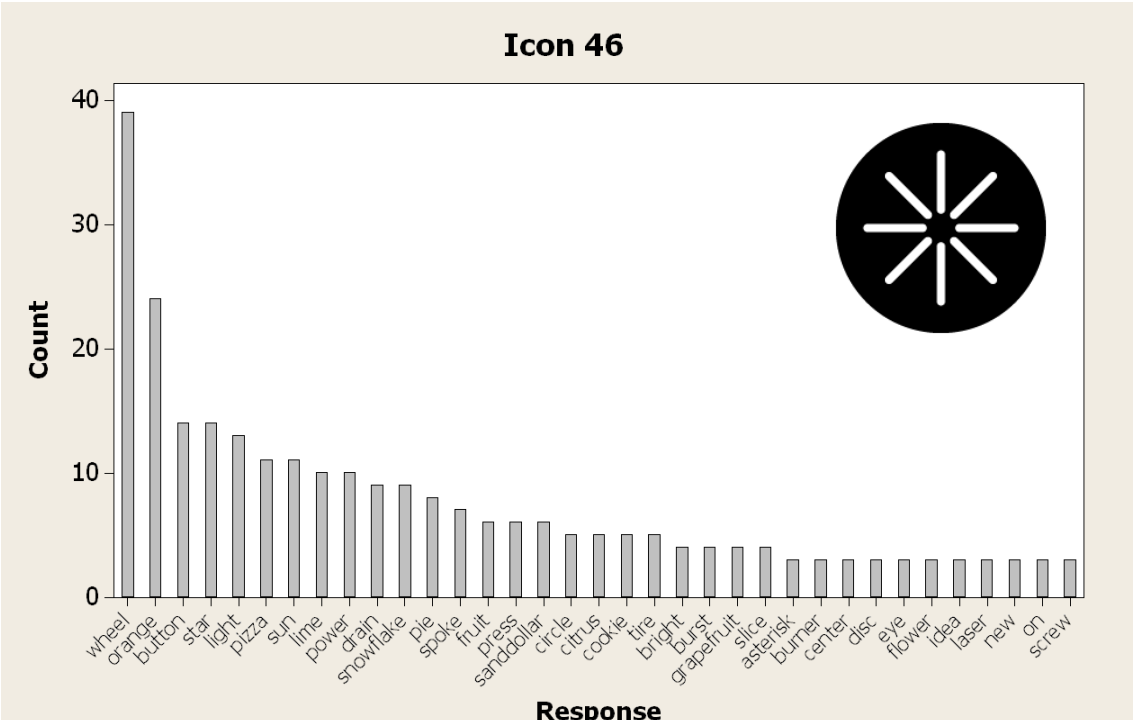
Graph 2 – Response Frequencies for Icon #16

This graph shows the response frequencies of each term (greater than two) for Icon #16. Only the responses equaling or exceeding a frequency of 10 were considered for analysis. Since "pacman" is the most popular response, it was set as the base.



Graph 3 – Response Frequencies for Icon #25

This graph shows the response frequencies of each term (greater than two) for Icon #25. Only the responses equaling or exceeding a frequency of 10 were considered for analysis. Since "lollipop" is the most popular response, it was set as the base.



Graph 4 – Response Frequencies for Icon #46

This graph shows the response frequencies of each term (greater than two) for Icon #46. Only the responses equaling or exceeding a frequency of 10 were considered for analysis. Since "wheel" is the most popular response, it was set as the base.

The Multinomial Linear Regression Analysis was applied to four of the 50 icons: #00, #16, #25, and #46. Ideally, all icons should be analyzed. For the purposes of this experiment, four were selected based on the response counts. Two icons that generated relatively flat response frequency graphs were chosen, that is, many responses that were similar in frequency of occurrence: #16 and #46. Two icons that generated curved response frequency graphs were selected, that is, icons which had varied response frequencies with a few dominant: #00 and #25. There were several graphs that generated curves too sharp for a worthwhile analysis such as #14, #20, #30, and #41, among others. These graphs were excluded because there was a clear favored response and, therefore, had too few response frequencies of 10 or over, if any. Many icons had similar graphs, but these numbers were chosen because the icon would yield a more interesting discussion. Also, some icons that had similar response curves were ignored, as the analysis was expected to be too similar such as #00 and #36. Icon 36 is ideal for analysis, but similar to icon #00, so icon #25 was chosen instead. Both icons #25 and #46 have response curves that are close to average.

How to Analyze Data

The analysis generated responses similar to this:

Category	Variable	Response	Estimate	StdErr	OddRatio	P
Color	green	power	3.316	0.9247	27.54993	0.0003

Base Response: ‘wheel’ Base Color: black

Table 9 – Color Computation Example

This table shows the computed data for one significant color interpretation differences. In the table, “category” denotes the type of data analyzed in that row, “variable” is the specific value being compared to the base, “response” is the specific participant-provided term, “est” is the estimate, “stderr” is the standard error, “oddratio” is the odds ratio, and “p” is the p-value, that must be less than or equal to 0.05 to be considered a significant change.

This table shows how results compare to each other. The “category” explains which variable is in question. In this case, the color data is shown. The “variable” and “response” columns show which particular attribute and term, respectively, are being compared to a base. The “estimate” column is the linear coefficient. The “stderr” column represents the standard error, which is a measure of how inaccurate the estimate might be. For the most part, standard error is relatively low. If high, there may be other factors affecting the data such as a lack of numbers to calculate. The “oddratio” column shows the odds ratio for each instance. This shows the probability that a participant would choose one response over another for certain conditions. The “p” column in the p-value, which if less than or equal to 0.05, shows there is a significant difference between the two conditions. In this row, the “green” “power” is being compared to “black” “wheel.” For most of the analyses (all but technical experience), the results are compared using a 2x2 contingency table, seen in Figure 18. This shows that a user is over 27 times more likely (based on the odds ratio) to say the icon represents “power” (the provided response) when it is green (the assigned color) than “wheel” (the base response) when it is black (the base color). This table shows the comparison of odds ratios for each situation (Agresti, 1990, pp. 14-17).

	Base Color 'black' (C_o)	Assigned Color 'green' (C_1)
Base Response 'wheel' (R_0)	$a = f(R_0 \wedge C_o)$	$b = f(R_0 \wedge C_1)$
Given Response 'power' (R_1)	$c = f(R_1 \wedge C_o)$	$d = f(R_1 \wedge C_1)$

Figure 18 – 2x2 Contingency Table

The table makes a comparison between two sets of variables for a univariate multinomial logit analysis.

Category	Variable	Response	Estimate	StdErr	OddRatio	P
Tech Exp	N/A	sign	0.3174	0.1612	1.373552	0.0489

Base Response: 'lollipop' Base Color: black

Table 10 – Technical Experience Computation Example

This table shows the computed data for one significant technical experience interpretation differences. In the table, "category" denotes the type of data analyzed in that row, "variable" is the specific value being compared to the base (which since technical experience does not use a base, is not applicable), "response" is the specific participant-provided term, "est" is the estimate, "stderr" is the standard error, "oddratio" is the odds ratio, and "p" is the p-value, that must be less than or equal to 0.05 to be considered a significant change.

The technical experience column looks similar to the color, except there is no specific comparison, hence there is no variable listed, as there is no base. Technical experience is quantitative and, therefore, measures differently from the other categories. Instead of comparing this to a base, it compares to the adjacent numbers. Technical experience was chosen on a

Lickert scale from 1 to 7, where 1 is “very experienced” and 7 is “no experience,” and all other factors in between are proportionally distributed. The “estimate” column in this case represents the coefficient of a linear function, as illustrated in Figure 19. In this example, the likelihood that a participant will label the icon as “sign” instead of “lollipop” will increase by 0.3174 for each interval that technical experience decreases. Therefore, a participant of technical experience level 7 is six times the estimate more likely to label it as “sign” than someone of level 1 will label it “lollipop,” which is almost twice as likely.

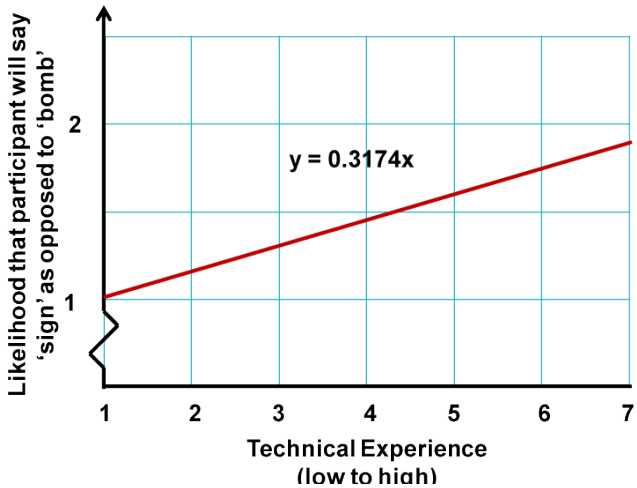


Figure 19 – Comparing Technical Experience using Estimate as Coefficient

The estimate is the coefficient used in a linear formula. This compares the technical experience levels from 1 to 7 against each other.

Icon Data Analysis

The analysis for each icon required the use of the multinomial logit analysis. The data were collected for each icon and placed in the SAS program for analysis. A code was written to handle the calculations (seen in Appendix D) and modified to compare each variable against a base.

Listed in the upcoming tables are the significant differences in the analysis. A significant difference is considered to be any instance where the p value is less than or equal to 0.05. A complete analysis is shown in Appendix D.

In some of the following cases, there was insufficient data to develop a proper conclusion. For example, an odds ratio may state that something is 20 times more likely than another condition. This is probably not the result of a significant difference in data groups but the lack of data. This was similar to a conclusion that if a coin is flipped and heads appears eight out of the ten, then the results are heavily weighted toward the probability of heads. This is incorrect, and more instances should resolve the strange statistics.

The country data was mostly insufficient for drawing any particular conclusion. The data could have been grouped into USA and non-USA data collections, but this would have defeated the purpose of analyzing the data from the participants of each country. Grouping Canada and China, for example, would not be a fair comparison, as it was expected that each group would be expected to yield differing response sets. Adjacent age ranges could be combined to form a larger group if necessary. Since the data contained few participants who were age 61 or over, this could be grouped with the range below, which was 46 to 60. Therefore, a new category, age 46 or over, would be created. For the most part, there is sufficient data to describe the age ranges as they stand.

Icon #00

Category	Variable	Response	Estimate	StdErr	OddRatio	P
Color	blue	bottle	1.0245	0.4899	2.785702	0.0365
Color	blue	flask	1.1548	0.4823	3.173389	0.0167
Gender	female	ornament	0.7375	0.3573	2.090702	0.039
Gender	female	time	-0.8187	0.3493	0.441005	0.0191
Tech Exp	N/A	time	0.474	0.1994	1.606407	0.0174
Age	61over	time	3.7316	1.0184	41.74585	0.0002
Age	46to60	flask	2.1954	0.4487	8.983594	<.0001
Age	46to60	grenade	1.3554	0.4956	3.878312	0.0062
Age	46to60	perfume	1.43	0.578	4.178699	0.0134
Age	46to60	bottle	1.6455	0.4846	5.183601	0.0007
Age	46to60	timer	1.2912	0.571	3.637149	0.0237
Age	31to45	time	2.1009	0.6333	8.173523	0.0009
Age	31to45	flask	1.1305	0.4802	3.097205	0.0186
Age	31to45	grenade	1.2728	0.4456	3.570837	0.0043
Age	31to45	perfume	1.8	0.4641	6.049647	0.0001
Age	31to45	bottle	1.9179	0.4001	6.806649	<.0001
Age	31to45	timer	1.692	0.4777	5.430331	0.0004
Age	31to45	clock	3.4845	0.4134	32.60612	<.0001

Country	canada	grenade	3.0057	0.8141	20.20035	0.0002
Country	kazakhst	perfume	-4.2223	1.3873	0.014665	0.0023

Table 11 – Icon #00

This table shows the computed data for the significant changes of values against a base variable. In the table, "category" denotes the type of data analyzed in that row, "variable" is the specific value being compared to the base, "response" is the specific participant-provided term, "est" is the estimate, "stderr" is the standard error, "oddratio" is the odds ratio, and "p" is the p-value, which must be less than or equal to 0.05 to be considered a significant change.

Bases: Response: "bomb", color: black, gender: male, tech exp: age: 18 to 30, country: USA

If the icon is blue instead of black, people were almost three times more likely to label it as "bottle" than "bomb," and over three times more likely to label it as "flask" as opposed to "bomb."

In terms of gender, females were twice as likely to label the icon as "ornament" than "bomb," and men were over twice as likely to label it as "time" than "bomb."

Technical experience shows a significant difference in one instance. As technical experience increases, the chance a participant will say "time" as opposed to "bomb" increases almost .5 times each interval. Taking the two extremes, a level 1 expertise, the highest, and level 7, the lowest, will show an increase of almost three times.

There were several significant differences in response probabilities among age groups. People 46 to 60 were almost nine times more likely than 18 to 30 year olds to describe it as a "flask" instead of a "bomb." The age group ages 61 and over were over 40 times more likely to describe the icon as "time" than "bomb" as opposed to 18 to 30 year olds. Ages 31 to 45 are over eight times more likely to describe the icon as "time," over six times "perfume," almost seven times "bottle" and over 32 times "clock" than 18 to 30 year olds are "bomb." This may have been the result of a lack of data. These described were among the most significant and noteworthy changes.

It was difficult to calculate meaningful results of the icon interpretation across countries due to few individuals participating from each country. Canada, however, had sufficient participants. Canadian participants were over 20 times more likely to identify the icon as a "grenade" than USA participants as "bomb."

Icon 16

Category	Variable	Response	Estimate	StdErr	OddRatio	P
Color	red	circle	3.0996	0.8173	22.18907	0.0001
Color	red	cut	1.8636	0.7032	6.446904	0.008
Color	red	slice	2.8133	0.723	16.66482	<.0001
Color	orange	circle	1.5906	0.7893	4.906692	0.0439
Color	blue	slice	3.9773	1.0998	53.37273	0.0003
Gender	female	slice	2.2466	0.9071	9.455532	0.0133
Tech Exp	N/A	slice	-1.6155	0.7796	0.198791	0.0383
Age	46to60	chart	2.0667	0.8881	7.898714	0.02
Age	46to60	open	1.6184	0.8034	5.045012	0.044
Age	46to60	cut	1.9267	0.8043	6.866812	0.0166
Age	31to45	circle	-2.1196	0.9488	0.12008	0.0255
Age	31to45	open	1.4912	0.6918	4.442423	0.0311

Table 12 – Icon #16

This table shows the computed data for the significant changes of values against a base variable. In the table, "category" denotes the type of data analyzed in that row, "variable" is the specific value being compared to the base, "response" is the specific participant-provided term, "est" is the estimate, "stderr" is the standard error, "oddratio" is the odds ratio, and "p" is the p-value, that must be less than or equal to 0.05 to be considered a significant change.

Bases: Response: "pacman", color: black, gender: male, age: 18 to 30, country: USA

There were several difference values that were significant for color for this particular icon. Among the most interesting was the change from red to black. When the icon was red, people were over six times more likely to describe it as "cut," over 22 times as "circle," and over 16 as "slice" than as "pacman" if the icon was black. If the icon was orange, people were almost five times more likely to describe it as "circle" than "pacman" if it were black.

Females are almost 10 times more likely to describe the icon as "slice" than men are "pacman."

There was only one instance of significant difference among technical experience levels. The data did show that as technical experience decreased, participants were almost two times more likely to say "slice" than "pacman" for each interval.

Country was ignored for this experiment. The USA value could not be set as the base for this analysis, and as a result this was discarded. Country information was included mostly as a measure of bias. Since not enough people participated from countries outside the US, this comparison is not necessary.

Forty-six (46) to 60 year olds were almost eight times more likely to describe it as a “chart,” five times more likely to say it means “open,” and almost seven times more likely to say “cut” than 18 to 30 year olds. People ages 31 to 45 are over four times more likely to describe the icon as “open” than 18 to 30 year olds, and the 18 to 30 age group are over eight times more likely than the 31 to 45 year olds to say it means “circle”.

Icon 25

Category	Variable	Response	Estimate	StdErr	OddRatio	P
Color	red	female	1.6467	0.584	5.189825	0.0048
Color	red	head	1.7003	0.6294	5.47559	0.0069
Color	blue	female	1.7201	0.5622	5.585087	0.0022
Color	orange	female	1.672	0.6392	5.322803	0.0089
Color	orange	head	1.4588	0.642	4.300795	0.0231
Color	green	head	2.0885	0.5673	8.072797	0.0002
Tech Exp	N/A	sign	0.3174	0.1612	1.373552	0.0489
Age	46to60	person	1.2576	0.464	3.516971	0.0067
Age	46to60	search	1.8198	0.581	6.170624	0.0017
Age	46to60	sign	2.1763	0.3537	8.813635	<.0001
Age	31to45	person	2.2036	0.3584	9.057562	<.0001
Age	31to45	sign	1.9467	0.3445	7.005531	<.0001
Age	31to45	female	1.9679	0.6063	7.155634	0.0012
Age	31to45	key	1.3698	0.6143	3.934564	0.0258

Table 13 – Icon #25

This table shows the computed data for the significant changes of values against a base variable. In the table, “category” denotes the type of data analyzed in that row, “variable” is the specific value being compared to the base, “response” is the specific participant-provided term, “est” is the estimate, “stderr” is the standard error, “oddratio” is the odds ratio, and “p” is the p-value, which must be less than or equal to 0.05 to be considered a significant change.

Bases: Response: “lollipop”, color: black, gender: male, age: 18 to 30

Country was not analyzed due to insufficient data.

Color was a significant factor in this icon. First, the data states that people were over five times more likely to label the icon as “female” when it was red then when it was black. The same was true for the icon being blue or orange instead of black. They were also over four times more likely to label the icon as “head” when it was orange than when it was black. With orange, it was over four times more likely, and green, over eight.

No significant changes in response across gender were found in this analysis.

Technical Experience did not show much difference. However, the data shows that people are over three-tenths times more likely to say “sign” than “lollipop” for each interval of increasing technical expertise.

The data for country was insufficient and, therefore, could not be analyzed. USA could not be made as the base value and, therefore, would be too difficult and vague to analyze.

Age range showed many notable differences. Ages 46 to 60 are over six times more likely to label the icon as “search” and almost nine times as likely to label it “sign” than 18 to 30 year olds. Ages 31 to 45 are over nine times as likely to report the icon as a “person,” and over seven times more likely to label it as “sign” or “female” than 18 to 30 year olds. Participants were over seven times more likely to say the icon appeared as “head” than “lollipop” in the 31 to 45 age group.

Icon 46

Category	Variable	Response	Estimate	StdErr	OddRatio	P
Color	orange	sun	2.5317	0.6314	12.57487	<.0001
Color	orange	orange	1.4054	0.5616	4.077157	0.0123
Color	green	power	3.316	0.9247	27.54993	0.0003
Color	blue	lime	5.8156	0.5398	335.4926	<.0001
Color	blue	sun	2.0021	0.7319	7.404589	0.0062

Table 14 – Icon #46

This table shows the computed data for the significant changes of values against a base variable. In the table, “category” denotes the type of data analyzed in that row, “variable” is the specific value being compared to the base, “response” is the specific participant-provided term, “est” is

the estimate, "stderr" is the standard error, "oddratio" is the odds ratio, and "p" is the p-value, which must be less than or equal to 0.05 to be considered a significant change.

Bases: Response: "wheel," color: black, gender: male

Age and country were not analyzed due to insufficient data.

This icon contained the fewest significant differences. There was not enough data to compute age or country, so results were limited. Color yielded some noteworthy results.

If the color was orange instead of black, people were over four times more likely to identify it as "orange" than "wheel." Also, if the color was orange instead of black, people were over 12 times more likely to identify it as "sun" instead of "wheel." When the icon was green, people were over 27 times more likely to label it as "power" than wheel. When blue, the icon was more than 355 times more likely to be labeled as "lime" over "wheel." This indicates that probably no participants labeled the blue icon as "wheel." The participants also were over seven times more likely to label the icon as "sun."

Age range and country of residence were not analyzed for this icon due to the lack of data necessary to perform the multinomial logit analysis.

Discussion

The findings reported in this thesis are important in many venues. First, the general public uses icons on a daily basis on bathroom doors, computer programs, and products, among others. It is important that the icons be clear and understandable to the targeted demographic. Computer professionals, such as web and software developers, should be aware of how the viewer may interpret the icons they develop. Ideally, each viewer should arrive at the same conclusion about what an icon represents, but it may not always be possible. The findings from this study offer insight for professionals, as it will guide them in the proper direction for icon development and show that demographic profiles and icon color can affect interpretation significantly.

Icon designers may also consider running a similar experiment to test the interpretability of their libraries. This is particularly important for certain domains that require icon clarity such as in danger signs or international symbols.

Observational Analysis

Several noteworthy observations were apparent in the experimental data.

One of the most noticeable trends in the data was that the participants chose not to comment on certain icons. Although it was explained in the directions that participants should provide responses for all icons, some found ways to pass. Instead of providing a description, some participants wrote “no idea” or something similar, as they were required to write a response for each icon but could not decide on a descriptor. Some participants may have written this or a similar phrase with the intention that it is the interpretation. However, if the participant wrote this in response to several icons, we understand that the participant was merely waiving the opportunity to provide a response. Some participants wrote emails saying that they took the survey and provided such responses when they could not deduce the icon’s meaning.

Some users provided responses such as “don’t know” or “this survey is too long” for certain icons. This reinforced the importance of usability. Icons must be clear; otherwise the observer can become frustrated.

Another observation based on the response data was that participants often stated that the icon is “on its side,” “upside down,” or “turned around.” This may have demonstrated the ability to make sense of abstraction.

Though mental rotation could have helped a viewer interpret an image, it may have also limited one's ability to see an object for what it is. If one described an image as something "on its side," that could have meant that their interpretation of that object was so powerful that they did not consider interpreting the graphic at its original orientation. It could have also meant that the icon did not make immediate sense at the presented angle. This caused some problems with the survey. Some participants noted in their responses that they were seeing an image more than once. It was most likely the same image but with different orientations. The viewer saw the image and described it. If the viewer sees the image later under a different rotation, they might interpret it similarly.

Another observation was how people described the abstract images. When people communicate verbally or in text, it is oftentimes difficult to convey the entire expression through words. Speakers resort to hand signals, bodily gestures, sounds, or visual references to help explain a concept. Writers can reference images, graphs, or charts in order to help convey meaning Participants in this survey sometimes referred to a shape as a "V." Instead of describing the shape itself, they resorted to an alphabetical cue with which most were familiar to describe the icon's shape. In communication, it is often acceptable to describe something as the shape of a letter or number to create a mental image. Other analogies can be used as well.

Some participants also described the icons using negated properties. For example, icon #11 looked quite similar to the Star of David to many observers. Instead of describing the shape as something, they would use the commonly understood Star as a benchmark and describe the shape as "almost star of david" or "not star of david." The latter, instead of saying what the object was, said what it was not. Still, saying something is "not" something is a poor descriptor, as it does not offer any insight to what the object is. However, in this case, one could have observed other's descriptions and seen that "not" actually implies a similarity such as "akin."

Reflection on Literature Review

As discussed in the literature review, colors induce certain psychological and physiological reactions in humans. Colors can evoke emotion or convey deeper meanings based on either innate understanding or learned psychological associations. Color invoked significant differences in the interpretation of the icon. In many cases, participants who interpreted an icon as meaning something in particular when black construed it differently when it was a color. Though it cannot be proven from this experiment and these results how the colors affected judgment, there is sufficient data and literature to draw a supposed conclusion. It is this investigator's opinion that

most of the interpretations matched the common patterns reported by color psychology (Birren, 1992, pp. 142-144, 257-261).

For most of the icons, it is this investigator's observation that most participants tended to label the icons of specific colors as something in nature that matched that color. For many responses, the foundations of color psychology could apply. In this literature review of this thesis, the effects of color on human perception are covered extensively but only describe a small portion of what is known. Red, blue, green, orange, and black all have particular associations (Birren, 1992, pp. 142-144, 257-261). Though the ideas of what color represents can vary across cultures, there are some generalizations that can be made. Red is a warm color that can represent emotions like love and fear and capture attention. It is used for alerts, since the color is so captivating. Blue is calming and part of nature. It is the color of water, has a cool feel, and is a particularly non-threatening hue. Green is earthly and natural. Many natural objects are green, and it is typically a mellow and relaxing cool color. It shares many properties with blue. Orange is similar to red. It is warm, energetic, and glowing. It is also seen as a more modern and metallic color. Black is perhaps the most powerful of all. It expresses a darkness and emptiness. It often has negative associations, representing death, depression, ominousness, and godlessness. Contrarily, black can also show submission to god, as priests wear black robes (Rousseau, 2008, pp. 14-16). It is a color of authority. White is a pure, positive color and usually represents peace and cleanliness.

The color psychology research somewhat supports the icon responses observed. Though the data does not show exactly why people labeled them as such, inferences can be made based on the data. In icon #00, participants were more likely to label the icon as "bottle" or "flask" if it were blue; perhaps suggesting that the blue color reminded the viewer of water or fluids. In icon #16, many participants labeled the red icon as "cut," possibly because red is a warning color and cut is a typically a dangerous gesture. Some also labeled the red icon "slice," along with blue, suggesting a similar action but more planned and safe. Many labeled the orange version of icon #46 as "orange," probably because the orange color makes the image look like a sliced fruit bearing the same color. "Sun" was also a popular response for orange, as it is a high energy, warm color, and often matches the color of the sun. The green icon was labeled as "power" by many participants. Since green is typically a permissive color, the participants may have been referring to a switch, where the green light represents a system that is powered.

Scientific investigations show that environmental factors may influence people's perspectives about color (Birren, 1992, pp. 179-181). Skylight and sunlight in certain regions of the world could affect one's color preference. Colder climates typically have higher skylight and less sunlight than warmer climates, since people are constantly exposed to certain environmental lighting

conditions, the eyes adjust accordingly. In environments with intense light, eyes may adapt and develop red-sightedness. The eye may also develop strong pigmentation in the foveal region. This typically happens with brunettes such as Latinos, as they typically reside in light-intensive areas. They usually favor warm hues, a result of psychological accommodation to long wavelength light rays. People from Nordic and Scandinavian regions are usually green-sighted and favor cool colors like blue and green. They may have different foveal pigments than their red-sided counterparts. Therefore, people who live in well-lit areas tend to prefer warm, bright, saturated colors. Those from areas where light is less abundant prefer cooler and softer hues.

Research shows that older people favor the color blue (Birren, 1992, pp. 179-181). This may be because eye fluid yellows over time. A the lens of a child's eye lens will absorb about 10 percent of blue light, whereas an older person would absorb about 85 percent.

Diet may also affect color preference (Birren, 1992, pp. 179-181). Since diet usually follows country of origin, this study has the potential to investigate this theory further. A study showed that Mexican children preferred colors of high discrimination such as blue, yellow, and red. When the diet was corrected to include more calcium, the children were able to appreciate more subtle differences between colors.

A multivariate approach may reveal new information that pertains to this research, as the results would then show how older people would interpret blue icons against others.

When looking at the graphs, it is clear that many people showed significant agreement on what certain icons represent. This is because the first response on the graph is high (usually a frequency of around 200 or higher) with a small frequency for other leading responses. These icons are #10, #12, #13, #14, #20, #22, #23, #24, #30, #37, #39, #40, #41, and #47. When observing these icons and comparing them to others whose responses were more diverse, it appears as though the "clear winner" icons are recognizable shapes. Icon #20 was said to represent "star," as it was a star shape. The polygon is clear and recognizable, so many participants decided to label it as they saw it. Others decided to give it a deeper interpretation, saying it represented "favorite" or something similar. The simple shape evoked a near consensus on the icon's meaning. Icon #30 was not a common shape. Most people said it represented "bridge". The reasoning for this is probably because this image was an uncommon shape and may not match other figures found in nature.

Some icons are more ambiguous than others. This is based on the shape of the response frequency graphs. The icons that generated flatter graphs or those that plateau are labeled as

more ambiguous because the response frequencies are similar, and there may be no clear winning response. Graphs that have one response with a high frequency and other responses with frequencies significantly lower are typically more understandable, as the participants labeled it similarly. It appears as though the most recognizable icons are the figures that either clearly look like a specific noun or do not fit another possibility. For example, upon first glance an icon may look like it has several different meanings. After some thought, one particular meaning will make more sense than the others, so that is the one that will be noted. Ambiguous icons may look like more than one thing or nothing at all. A particular shape may look like many things, so it will be ambiguous. Other shapes may look like nothing at all and, therefore, people are more likely to arrive at different conclusions about what an icon represents.

Some icons were designed by the author of this thesis to be abstract. This meant it was drawn to represent nothing in particular (meaning no object or common shape). They are modeled after nothing and, upon observation of the icon, should not invite an obvious response. In this study, the five icons, #03, #06, #40, #42, and #47, are labeled as abstract. There is no clear correlation in the response sets for each. Some generated flat response frequency graphs, showing that there are no clear winners for responses, and others generated a near consensus for interpretation. If a later experiment is conducted to measure the amount of time it takes to arrive at a conclusion for a response to the icon, it may reveal that the abstract icons take longer to identify.

Multivariate Approach

This analysis takes a univariate approach. The comparisons are always between one datum and the base datum. A multivariate approach will offer more insight between data points. For example, the data in this study may indicate that if the icon is a particular color, someone is more likely to use one term than another than if it is black. Also, a certain age group may be more likely to use one term and the base age group would use another. These comparisons are shown for each of the analyzed icons. However, there is nothing showing how a particular age group interpreted a certain color. A multivariate analysis would calculate this information and perhaps reveal some relevant and significant findings.

Experimental Problems and Variables

The data collected from the website may not have been accurate. If users worked in teams, submitted answers without analyzing the image, or did not understand the site's instructions, data could have been skewed. The experiment can only screen for certain variables. The screener

does not protect from the user lying about any demographic details or providing incorrect information. The participants are free to enter any valid information regardless of accuracy.

Because the users had the option to provide an email address, they may have thought that their information would be shared in a way that is associated with their identity, although it was stated in the terms that it would be kept secret. This may affect the answers they give for the icons. Having some users enter an email and others not may also skew the results, as conditions are not the same for every participant.

The population of participants could also have hastily completed the test in order to have the best change for winning the incentive. They may not have taken care to analyze the symbols that they should have. Participant carelessness (or seriousness) could have affected the results. Participants also may have avoided writing a particular response because they thought it was foolish, unclear, or rude. The initial interpretation is most important.

The time required to load a page varies due to connection strength, bandwidth, platform, and browser. The time between each image presented most likely varied between participants. Since this period of rest is not the same, this is a variable that must be noted.

Certain entries may have been missed when editing the responses and preparing them for analysis. Some may have been edited incorrectly, or there may have been inconsistencies in data refinement. Words that were corrected for spelling may not have been errors or may have been a different word. If an error occurred in this step, it would be insignificant.

Browser and monitor display settings may also influence the viewer's interpretation. Flickering of the monitor, unusual aspect ratios, color and gamma malfunctions, and varying screen size, brightness, and image resolution, are all factors that may hinder the quality of the results. However, this experiment is supposed to collect data from users in their usual situations. If a monitor is out of focus, flickers, or displays too small, it is indeed a variable, but the experiment is run in the user's environment. If the user were to use another software application, the same variables would apply.

Varying environmental conditions such as lighting, noise, distance from monitor, typing ability, and participant nervousness or anxiety, could affect results.

Improving the Experiment

Correcting any of the aforementioned issues should improve the experiment's accuracy and reliability. In order to yield the best results, these variables should be minimized or eliminated. Since an experiment must be replicable, the conditions involved should always be the same in an ideal situation. However, this is not always feasible.

Increasing the number of times the experiment is performed should yield more accurate data. Increasing the number of samples can add value to almost any experiment. In this case, more participants would make the results more valuable and accurate. It would also increase the chance of identifying trends and spotting details in the responses that are worthy of note.

In order to properly analyze the demographic information, the numbers for each group should be about the same. In this particular case, there were some groups that heavily outnumbered others such as the number of participants from the United States or the 18 to 30 age group. Of course, having greater quantities of each group would eliminate bias as well. For example, one age 60 and over person could have analyzed a particular icon that was green. Therefore, that one response would statistically represent the entire over 60 population, compromising the data's integrity. Each demographic profile should have seen each color in every icon at least ten times. This is one reason why the country of residence data was discarded; there were too few participants to generate accurate results.

Conclusion

Icons are open to interpretation, as are art, music, and literature. An icon will not have a single interpretation, though it may be designed to convey one particular message. Variables in icon color and demographic profile affect interpretation, as does the discretion of the individual. Unless a regimented system with agreed meanings is used such as in written language or mathematics, the visual will be subject to interpretation.

Words are typically clearer than icons but can still be open to interpretation. For example, “heart” could imply a measure of vitality, devotion, care, an organ, a shape, or love. It is simply not clear. Icons have similar problems.

Until an unambiguous system is developed, designers must consider the shape and color of the icon and the targeted demographics to design effectively.

The icons that seemed to have responses that were clear winners, or had the greatest curvature, were typically the ones that were clear and looked like a familiar object. Most individuals who identify these will give an absolute answer and then may proceed to make more abstract interpretations. Those which generated more varied responses with flatter curves were generally more abstract and represented nothing in particular. Participants identifying these icons may arrive at a vague conclusion after considering the icon.

According to the results, demographic profiles do affect icon interpretation. In some icons the change is noticeable and significant. However, color seems to show an even greater change. Most icons in the library show a significant change in response across colors for the general populace. The changes usually follow the evidences of color psychology, where specific colors evoke certain reactions. Also, participants typically described colored icons as a shape that would usually be that color.

Further Experiments

This site could be modified to function as a public tool for choosing appropriate icons, serving as a reference. A library of icons could be added to the system and participants encouraged taking the same test presented in this thesis. The data would be collected and analyzed automatically, and then the data would be stored for each icon. If one is contemplating the best way to draw a "light" icon, they can type "light" into the search engine and that will search the database and show how many users used the word "light" to describe each icon. The designers will see the icons matched with the top descriptors the users provided. It also should work in reverse. Designers can upload their icons to the system for others to analyze and interpret. After enough people have voted for the proper terms to describe the image, the time survey opens. People will then vote using the new survey. After gathering enough data, the image is shown in the results section with the data. This system will be a growing database of icons and descriptions. Developers can use this system to select the optimum symbol for an interface. The more submissions there are in the survey, the more information the results will produce.

This experiment could be continued by seeing how far the icon can shrink before it is no longer recognizable or interpretable. A study could also involve describing an icon that is part of a series or adjacent to others.

The main variable forced upon the population in this experiment was color. Other image modifiers would also make suitable variables. Changing the size, display time, tint, shade, orientation, or level of detail of the image could yield noteworthy results.

Later experiments could also involve the use of more colors, a larger icon library, or perhaps the combination of various colors. Since icons are a form of language, their clarity depends on how easy that language is to understand. Graphical elements could be investigated to test if they hold significance such as a circle with a strikethrough. Tying these elements in with other graphics may change the meaning of the image.

This tool could be expanded to increase versatility, reliability, and effectiveness. Adding more demographic profiles to the background questionnaire and allowing the addition of animated images may increase the usefulness of the system. Inviting more participants to partake in the experiment should improve the data. Performing this experiment on different audiences or sample sets should also generate data worth investigating. Expanding the sample set in a similar audience as tested in this thesis should generate similar data. Surveying new audiences may generate new trends.

This analysis utilized a univariate approach. This was effective enough to reveal how variables affect the responses. However, there is probably much more to analyze. A multivariate analysis will compare multiple variables at once. This is certainly a research opportunity that may be explored in a further iteration of this thesis. A multivariate approach should reveal more about the comparisons and trends, revealing more about the interpretation psychology.

Further experiments could be conducted using other colors. For the sake of simplicity, this thesis used only black and four colors. Icons can be any color. Though the data may not show significant change between minor color discrepancies, it may be worth investigating other primary or secondary colors and varying tints and shades. It may also be worthwhile to investigate other icons. Adding new designs may reveal new information about how people interpret icons with various properties. New experiments could also involve changing the size, rotation, level of detail, or context of the icon. Context is particularly interesting, as there are numerous experiments that can investigate this principle. It is worthwhile to study how people interpret icons in a particular context or how the surrounding icons would affect interpretation.

The goal of this thesis is to contribute to establishing a paradigm for creating clear and intuitive icons. Symbols are meant to replace text for clarity and efficiency. If the icon is unclear, it fails to do its intended job. Ultimately, a set of uncompromising standards should replace the current designer's ad-hoc approach. Though it may limit artistic creativity, it should change iconography for the better, making symbols intuitive.

Appendix A - Online Survey

Hardware and Software

The survey resided on the domain http://www.iconstudy.com. The website was composed using plain text editors such as Microsoft Notepad and Adobe Dreamweaver. All formatting was done in HTML with CSS managing the visuals and dynamic elements of PHP governing the content presented on the page. JavaScript manages dynamic client-side processes. The databases were managed through PhpMyAdmin, a tool developed for simple and secure data management. All communication with the database was written in MySQL and PHP.

The server for www.iconstudy.com was Apache version 2.2.9, UNIX. The operating system was Linux kernel version 2.6.27-grsec. MySQL was version 5.0.67-community-log, and the PHP version was 5.2.8.

Design

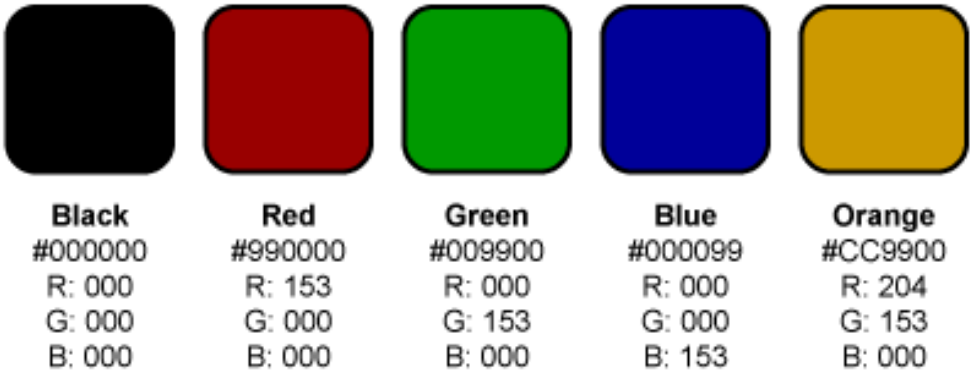
The site promoted usability, easy learnabililty, and speed of use. It was constructed to be intuitive to new users. Participants should have known how to use the site immediately and have as few steps as possible to ensure the user is progressing without interruption. The pages loaded quickly, the buttons were clear and intuitive, and transitioning through the images should have been easy.

The design contained little color, plenty of white space, and washed-out graphics. Any graphic that was too bright or distracting could affect the test. Fonts (Arial, Helvetia, and Sans Serif) were used for versatility and readability. Sans-serif fonts are more readable on screen than serif fonts. These fonts work on most standard machines, adding versatility to the site. The graphics were common file formats such as gif, jpg, and png, and did not contain transparent elements. This allowed the site to work in modern and recent browsers.

Icon Library

This study involved a series of 50 figures. Each composite was saved as five different colors: black, red, green, blue, and orange. The hexadecimal equivalents for each were #000000, #990000, #009900, #000099, and #CC9900, respectively. Each icon had a white background. All icons were developed in Adobe Illustrator, a vector-based design tool. This software allowed the

icons to be any size without losing quality. It also allowed for the easy changing of colors for each figure.



.

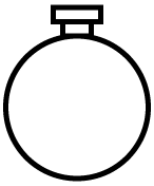
Figure 20 – Icon Colors

The colors for each icon figure with the hexadecimal and RGB equivalents.

The images were saved as gifs for maximum optimization. This allowed the images to load quickly without sacrificing quality.

Each symbol in the library had a reason for its placement. Some were purely abstract symbols presenting themselves as simple shapes or complicated figures with a difficult-to-distinguish shape. Some symbols varied in complexity, size, rotation, and context. Some symbols were comprised of other symbols such as arrows and lines. Each symbol was designed to be clear and legible as symbols should be. This also made them easy to interpret in all colors and helped reduce variable factors such as one's eyesight strength, screen resolution, and distance from the monitor. Each icon was designed so that it would not be offensive.

Pictured below are the 50 icons used in this experiment, complete with a description of the shape and an explanation of how viewers might have interpreted it, how color is a factor, and which icons share similarities with others.

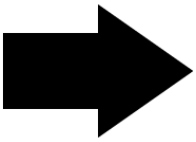


Icon 00

This icon is an outline of large circle. At the top, two small lines connect the upper part of the circle to a horizontal rectangle.

This is among the most versatile icons in the collection. It looks like many common objects such as a bottle, perfume, canteen, and stopwatch. This should generate abundant responses, many of which should vary depending on the demographic information collected. There should be numerous unique responses, but there may be several groups that occur frequently.

Color should change interpretation. If a viewer believes the icon represents a bottle of something, the color could dictate whether it is perfume (red) or water (blue). This is one possibility.



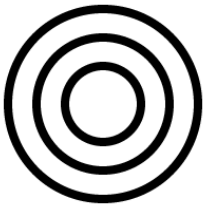
Icon 01

This shape, or some variation thereof, appears in many icons. It is commonly used as an arrow, which can have a variety of meanings. The arrow usually has a triangular head that indicates direction, usually by the different vertex of an isosceles triangle or, in many cases, a rectangular shape or line stemming from the opposite side. This particular arrow features a near equilateral triangle with a backend measuring a width about half the width of the side of the triangle it touches and a length about half the height of the triangle.

An arrow is expected to be a universally recognized symbol. They are used frequently in icons, so many might interpret this as an arrow without much hesitation. This test shows how people interpret the general shape. Many may say it represents an arrow, the direction “right,” or even a verb, indicating it performs a rightward action like moving. However, the icon may not be recognized as an arrow by all. Some may say it is a house on a slant or a tree, as the general shape is a common silhouette.

This was added to the library because it is a simple and common symbol that is used in many situations. Though many may recognize the shape as an arrow, it is unclear what they will think the arrow represents. The interpretation may vary with color.

Varying colors may affect interpretation in the same manner as one would predict based on color psychology. For example, a red arrow may be seen as a warning against performing an action in the indicated direction, and green may provoke actions in the respective direction. Varying colors may also affect how one interprets the overall shape.

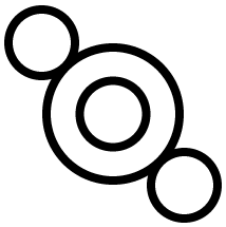


Icon 02

This icon is comprised of three concentric circles equidistant from each other.

This general shape is found in many places. Viewers may immediately recognize this shape and map it to objects that they have seen before. Some shapes include a target (or more specifically, dartboard), bull's-eye, stove top, or wheel. The lines of the circles are thick enough to represent a figure, outline, or even a background.

Color may also change interpretation. An orange figure may be seen as an abstract representation of the sun, while a red figure might invoke the recollection of a target.



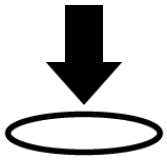
Icon 03

This design is comprised of four circles, three of which are the same size and a fourth which is about two times larger than the others. The three similar circles are arranged so they are spaced equally along a diagonal. A larger circle is concentric to the middle circle and touches the edges of the remaining two.

This icon is abstract and not intended to have any particular meaning. This should inspire a wide variety of interpretations for the user and may yield a longer response time, as it is suspected that this image will not

evoke an immediate response. This might represent any machine with rotating parts that touch each other.

Color might not offer much clarification of the image but may force the viewer to choose a shape with a similar color. Standard color psychology will also apply.



Icon 04

This icon is a filled, downward-facing arrow with a horizontal ellipse underneath.

It is typical that icon designers will use arrows to represent action. Arrows serve various purposes in imagery. This particular icon investigates how viewers interpret an arrow that appears to work conjointly with another shape. This shape features an ellipse underneath the arrow. The arrow is pointing downward, as if to affect the adjacent shape. The ellipse may also imply depth.

Viewers may see the arrow affecting or being affected by the ellipse underneath. The ellipse can represent many different cases. It could be a hole, and the arrow is indicating that something should be inserted into it. The ellipse could also be a flattened sphere, as regular objects appear unaffected, and skewed objects such as the ellipse appear to be a modified version of a regular circle. In this case, the arrow could be putting a downward force on the ellipse. The ellipse could also represent an independent object, and the arrow could indicate that the elliptical object should be pushed or moved in the respective direction. Arrows are also used to add emphasis to other objects. Perhaps a viewer may interpret this arrow as adding significance to the ellipse.

Color may affect interpretation in the way that typical color psychology predicts. This icon should represent an action or position more than a thing, so color is expected to influence the icon’s underlying meaning more than what it appears to mimic. Most interpretations should be verbs, adjectives, and prepositions.

Icon 05

This icon features two concentric octagons, one of which is slightly larger.

Many objects are octagonal such as nuts, bolts, stop signs, furniture, and knobs. Most individuals may interpret this shape as a stop sign, but there may be variances between culture, color, gender, and other factors that are being measured in this thesis.

This shape was chosen for this experiment because it is a simple, common shape that can be interpreted to have several meanings depending on one's personal experience and background demographics. This shape may also have varying interpretations based on certain colors.

Icon 06

This abstraction can represent a multitude of concepts. The image shows two lines that appear to be broken in the middle. The break extends two parts of the line, each in opposite directions, forming two sets of parallel lines.

The icon is not meant to represent anything in particular but may create varying responses based on one's background knowledge. Engineers may see this as a representation of a switch, as it shares similar properties with that industry symbol. Though these icons are not supposed to contain any alphanumerics, some may see this as "j" and "r."

Standard color psychology principles should apply, so color is expected to influence the results.

Icon 07

The shape is a circle with a symmetric protrusion from the bottom. The shape is filled with diagonal and horizontal lines. Stemming upward from the center of the upper line is a Y-shape.

This icon looks very much like a light bulb. This is a common depiction in icons and is worth investigating. The shape is almost unmistakably a light bulb but can have multiple representations. Some may see this as representing a bulb. However, the icon is used to represent an idea, on, thought, inspiration, and brightness. There are many suitable labels.

The color may change interpretation in many ways. First, since people may see this as a light bulb, the color of the icon may be associated with a light bulb. For example, orange may represent a bulb that is on and blue may represent off.

Icon 08

This icon is an abstraction comprised of a cross that breaks a large square into equal quadrants. A large outline of a square has four smaller squares on the inside flush with its border. The inside squares are slightly smaller than half the length and width.

This icon may take a while to be identified. This abstract design is not indented to mean anything in particular. This may stall the viewer's response, as there may be no immediate recognition of what this shape represents. This is commonly found in nature but does not represent anything in particular, therefore, taking longer for a viewer to recognize the image. The shape may look like many things, but the viewer may eventually decide to settle on an interpretation, not confidently labeling it in any particular way.

Most likely, the viewers will see this as a window, particularly when it is blue. The shape depicts a generic window found on many buildings. Some viewers may not be able to describe it as any one thing and instead will describe what it is instead of what it means and call it "squares."

Icon 09

This icon is abstract and not intended to mean anything in particular. The shape is comprised of a thick outer circle divided twice by two thin

diagonal diameters perpendicular to each other.

This is an abstract symbol and may have multiple, widely varying interpretations. Some may say it looks like a railroad symbol, as it shares many properties with the common sign that informs a driver that a railroad intercepts the street. It also looks similar to a wheel, as the outer circle can represent the tire and inner diameters represent the spokes. Some may say it looks like a pie, cake, or pizza cut into fourths.

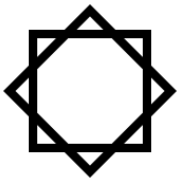
Since this shape is abstract, it is probable that color could offer new perspectives. Colors may narrow the wide variety of interpretations to more similar descriptions.

Icon 10

The image is comprised of several vertically aligned rectangles with two lines on the left and right equaling the distance between the arrangements of rectangles.

This particular icon is not meant to depict anything in particular. The shape is purely abstract. The idea of this symbol is to test the interpretation of patterns in icons. This particular icon has a vertically repeating pattern. Viewers will try to remember where they have seen a similar pattern before. Some may say it is a ladder, others might say tire treads. Some may see this shape as a repeating pattern that continues outside the pictures area, and others might see it as the entire shape.

Color may affect interpretation. When remembering where this pattern appears in nature, the color might be a factor to consider. If a viewer sees this image in green, the first thought might be to identify what green object this symbol depicts. Of course, there is also the prediction that the interpretation of this symbol will match the standard findings noted in color psychology.



Icon 11

This icon is two overlapping regular squares, one rotated 45 degrees over the other. This shape can be seen as being constructed in many possible ways such as an octagon with triangles off each side.

The abstract symbol represents many shapes found in nature and the environment, so the response set might be broad. It has rotational symmetry as well as reflective, like many natural patterns. It may resemble a flower or a sun. Many may say it is the Star of David, although that is comprised of triangles, not squares.

Color may change responses, as this shape can appear to represent many objects in nature. Having a particular color may limit the possibilities. If the icon is blue, it may look more like the Star of David, and participants may choose to identify it as such.

Icon 12

The shape is made from a filled circle. Around the circle, lines point in the direction of the circle's center.

This icon is most commonly used to represent the sun and used to communicate brightness, light, or an on switch. This is the intended interpretation for this image, but some may stray from the usual and define it as an explosion, a flower, or something else.

Changing colors may affect the viewer's interpretations. When orange, the icon will probably represent the sun. This may be the case for other warm colors such as red, as well. Cool colors may inspire different perspectives.

Icon 13

This shape is a crescent with the wider part of the shape facing left. The shape is made from a cutting oval inside a circle, producing the resultant

image.

The shape is a crescent, and many participants may identify it as one. However, many objects have this crescent shape such as the moon, a partially eaten cookie, or a sideways smile. Responses should vary. Many countries use this symbol on the flag, so the country of residence may affect the response set.

Color should influence the responses. This shape can represent multitudinous figures, but color should limit the possibilities. If this shape is presented on a logo or flag insignia, the colors must likely match for the viewer to connect the two ideas.

Icon 14

This icon shows three vertically aligned circles touching. The above circle is smaller than the one below it.

This icon is abstract but bears much resemblance to many common shapes. Most likely it will be interpreted as a snowman. It may also represent any situation where the above parts are smaller than those below such as the Towers of Hanoi. However, this game is not widely known, so users may not respond similarly.

Color could affect the icon in the typical manner dictated by color psychology research.

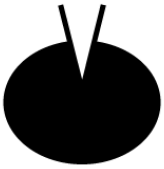
Icon 15

This icon is a filled circle with a v-shape stemming tangentially and meeting at the vertical.

The shape fits many figures such as a hot air balloon, ice cream cone, or a top view of a duck's head. The interpretations can vary, and be will probably change according to color.

Color may affect interpretation, as this particular shape can represent

many common figures. The color may narrow the possible matches, forcing participants to choose similar interpretations for colored icons.



Icon 16

This shape is a filled vertical ellipse that is overlapped by a triangular shape. The angle is made by two lines that cause the acute angle to point downward.

This icon is abstract but may look similar to a familiar object such as a needle and record, a piece of pie, or a wedge cutting into a fruit. This is among the more abstract icons in the collection and is not meant to represent anything in particular.

Color will probably affect the results based on current findings in human perception of color.

Icon 17

This icon depicts a filled rectangle with the longer part of an oval protruding from a longer side of the rectangle. The image is aligned so that the rectangle stands tall and the oval is to the right.

One may say that the icon looks similar to a coffee mug, as the shape depicts the body of the cup with a handle showing at its profile.

When seen in different colors, interpretation may stay similar. The various colors are not expected to affect too severely the way the shape is seen. The standard color principles will apply.

This icon works in conjunction with #15 and #16, which are different orientations of the same shape. These icons test the affect orientation has on the way one interprets them.

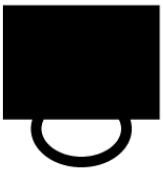
Icon 18

This icon depicts a filled rectangle with the longer part of an oval protruding from a longer side of the rectangle. The image is aligned so that the rectangle lies on its longer side and the oval is at the top.

Some may interpret this icon as a handbag, purse, or briefcase. In this case, gender may affect perception. These certainly are not the only interpretations that may show in the experiment.

Color may not change interpretation much, but if it does, it is expected that it will change based on the principles of color psychology.

This icon works in conjunction with #17 and #19, which are different orientations of the same shape.



Icon 19

This icon depicts a filled rectangle with the longer part of an oval protruding from a longer side of the rectangle. The image is aligned so that the rectangle lies on its longer side and the oval is at the bottom.

Some may interpret this icon as a ceiling hook or link, given its orientation. Certain participants may say this is a more obvious shape, like a suitcase or purse, upside-down.

Varying color may not affect the interpretation of this icon beyond the standard predictions in color psychology.

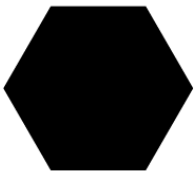
This icon works in conjunction with #17 and #18, which are different orientations of the same shape.

Icon 20

This icon is a star; a regular solid shape with five points of equal size and shape equally spaced from each other.

This icon is clearly a star. The goal of this shape is not to see if the viewer can recognize it as such but to see what the participants think it means. A star could have many meanings such as a satisfactory mark on a student's paper, a country's symbol presented on a flag, or something more abstract such as magic or high energy.

Color may be a factor. A yellow star is the symbol for favorites on websites and may be the highest response for people of the higher technical expertise demographic.

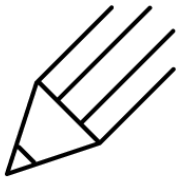


Icon 21

This icon is a regular filled hexagon.

This icon is abstract. It is a recognizable shape, but its meaning is open to interpretation. This does not represent anything in particular. It is predicted that users will interpret this as a hexagon. Users understand what the shape is and, therefore, will not invest the effort to exercise creativity in devising a more profound meaning for the shape.

Color will probably work similarly. Since the shape is obviously a hexagon, and the participants will probably label it as such, then colors, too, will probably be labeled as they are. If the shape of this is blue, the interpretation may be "blue hexagon."



Icon 22

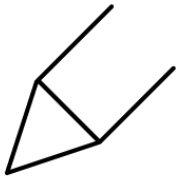
This icon is intended to depict a pencil or similar writing instrument. This is a common icon seen in many places, particular software and drawing applications. The pencil is among the most commonly understood writing

instruments, as they almost all look the same and have unique properties from other instruments such as a layer of graphite, wood, and an outer painted hexagonal shell.

It is predicted that viewers will not interpret this as anything other than a pencil but may describe it as an action such as “draw” or “write,”

Many pencils are orange in color, so the icon may be most recognized when it is colored orange. It is predicted that viewers will describe the icon as a pencil more than they would an action if it was orange. Other colors such as red, blue, and green will probably imply a verb such as “draw in the color green,” as a green pencil usually serves this function.

This shape also works with icons #23 and #24, which are similar, more simplistic versions of this caricature. This series will show how viewers interpret a shape of varied levels of detail.



Icon 23

This icon is a triangle with a set of parallel lines extending from the edges of the base.

It is drawn to represent a pencil or instrument for writing or drawing. The expected interpretation is that viewers will see this as a pen or crayon, as it lacks the distinguishing marks to make it a pencil as illustrated in icon #22.

Color will most likely matter. It is predicted that black, blue, and red will provoke terms like “pen,” while orange will make it look like a pencil. Bright colors such as green will most likely present the illusion of a crayon, highlighter, or other marking device.

This shape is similar to icons #22 and #24, which are similar versions of this icon. The series will show how viewers interpret a shape of varied levels of detail.

Icon 24

This icon is a shaded version of #22 and #23. It is a filled symmetrical hexagon with opposite edges of equal length.

This abstraction can have a wide variety of interpretations, but it is expected that people will recognize this is a writing device. The silhouette is the shape of icons #22 and #23. Viewers might recognize the shape and positioning of the figure as a pencil, as similar shapes are used in drawing and writing applications. The user's ability to recall might affect the interpretation. If one of the other figures is presented first, the participant might identify this shape similar to the others.

It is expected that color will affect the results. However, the effect will have little significance on interpretation. If the observers believe it represents a pen or other writing instrument, the color of the instrument might represent the color of the stroke.

This shape is similar to icons #22 and #23, which are more complex versions of this icon. The series will show how viewers interpret a shape of varied levels of detail.

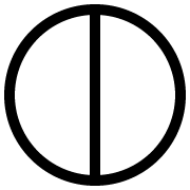
Icon 25

This shape is a line protruding from an outline of a circle so a vertical line stems from the bottom of the circle. The line is about the same size as the circle's diameter.

This icon was added to the library because it is abstract and open to interpretation. The shape itself if commonly found in nature, so a wide variety of responses are expected. This shape could also have symbolic meaning to some, creating more unique responses.

This shape is also abstract but can take on different interpretations based on color. The shape is commonly found in nature and could be an abstraction of several objects. If green, the viewer may see it as a tree.

The color blue may make it looks like a balloon, and red may make it look like a lollipop. If yellow, it may look like a key. The shape is simple and open to interpretation. The black icon could be any interpretation or a mix or the interpretations of specific colors.



Icon 26

The icon is a circle divided vertically by a straight line, making two semicircles.

This simple abstraction can represent many figures but relies on the viewer's imagination to relate it to something particular. A shape like this is expected to yield a varied response set. Abstractions typically force the viewer to use more imagination, so more interpretations are deduced. Some may label this as is, saying that it represents two semicircles. Others who use more imagination may see it as an exact representation of something less obvious such as a screw head. Some may describe this as an abstraction such as a cookie or opposing forces like love and hate.

The color may change the viewer's interpretation, but it is difficult to guess at how it might affect perception. This will probably follow the typical patterns in color psychology.

Icon 27

This icon is a square divided into four equal segments by three vertical lines. This forms four equal rectangles.

The shape is abstract but has rigid, memorable values. It is geometric and typically found in many man-made and common objects. The lines could represent bars on a window or perforations on a candy bar.

Color may affect interpretation based on the standard color psychology principles, and the response set should be predictable.

Icon 28

This icon is a filled polygon with a flat bottom and three points arranged symmetrically. The middle point is almost twice as high as the others.

Although not meant to represent anything in particular, this shape may be seen as a simplification of recognized figures. The shape may appear as a crown, mountain range, or fire, as the shape could be intuitively depicted to represent any one of them.

Color will most likely affect interpretation. It is predicted that each major response will show under each color, but the leading response will vary. If the shape is red, it is likely someone would refer to it as fire. If blue, the shape could appear as mountains or a glacier.

Icon 29

This shape consists of two identical filled crescents joined at their points. It could also be described as a filled circle with an empty ellipse stretched to both ends of the horizontal diameter.

The shape is generic enough to resemble many figures but will probably most commonly represent an eye. Most likely participants will identify this with shapes seen and noticed frequently such as facial features.

The icon's color should affect the interpretation. A blue icon should make the user think of an eye, but red might make it appear as lips or a beach ball.

Icon 30

This icon is complicated. First, a thick line extends horizontally. Below the line, three symmetrical thinner lines extend vertically from the bottom. From the top of this line, two lines extend upward. At the top of these lines, concave semicircles connect the tops of the line.

This icon was initially designed to resemble a bridge. The idea is to show a detailed caricaturized icon of a certain figure. Although it is meant to spear one way, others may see it as another shape, like teeth, a tent, or telephone poles.

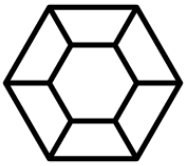
Color may affect interpretation. At first glance, this should appear to most participants as a bridge. However, if the icon is red, a color not commonly associated with bridges, it may be seen instead as a circus tent.

Icon 31

This icon is a quadrilateral stemming from two lines crossed perpendicularly. Basically, the shape is a cross with the ends connected by lines.

The shape is simple and may clearly represent common figures. It is predicted that many will say this looks like a kite, a shield, a diamond, or a gem.

Color should certainly affect interpretation. A black icon may appear as anything and is open to the viewer's interpretation. If red or orange, it may represent a precious stone. Using natural colors like green or blue may yield responses such as a kite.



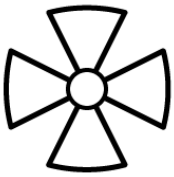
Icon 32

This icon is a regular hexagon concentrically aligned with a larger regular hexagon, and each edge is connected to the respective edge of the other with a line.

This shape is common in many man-made structures. It is geometric and rigid and usually figures are made to this shape for functional or aesthetic purposes. To some this may represent a hexagonal bolt. Some may refer to it as a gem, as it is similar to a common cut.

Color should certainly affect response. A colored icon may represent a

jewel, and a blue, green, or black icon may appear as a bolt, as they are cool, metallic colors. Participants may see orange as a honeycomb.

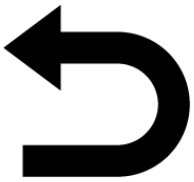


Icon 33

This shape has rotational symmetry. A small circle resides in the center. Lines stem from the center point and the ends are connected with an arc.

The shape resembles a fan. Some may see it as a hazmat or cautionary symbol, as it appears similar to the icons used to represent it.

Colors may affect interpretation in a typical way. The usual discoveries in color psychology should apply.



Icon 34

This icon is a filled u-shape with a triangle at one end pointing in the direction of the line.

Arrows are common elements in icons that are used to indicate direction. In this case, the arrow appears to have the form of a u-shape and looks as though it changes direction. The icon is meant to draw the eye from the base to the arrow tip. The icon is similar to the u-turn symbol used on traffic signs. Observers will probably identify it as such. Others may see this as a signal to turn.

The interpretations may change based on common color psychology. For example, if this icon in black represents a u-turn, it may seem to prohibit turning if the color is red.

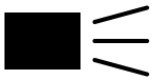
Icon 35

This icon depicts a filled box and a thick semicircle connected to the box by two lines of equal width.

The icon clearly resembles many objects such as a lock or a purse. The

interpretation should be varied and certainly numerous.

Demographic information, as well as color, should influence the interpretation. Women may see this as a purse while men may see it as a lock or bag. Color should also influence it, as orange may make it look like a lock, and blue or red a purse or bag.



Icon 36

The icon is simple but open to interpretation. A filled black horizontal rectangle has three lines to the right of it, all of equal length. The top and bottom lines are angled, and the center line is horizontal

The icon is abstract and not meant to represent anything in particular. This icon is particularly interesting because of the lines that may represent something intangible. The object could appear to be moving to the left, as the lines behind it represent motion. The object could also be projecting something like light or sound rightward, as noted by the lines. It may appear as an action or an object.

Color will probably change interpretation according to standard principles. An expected response could be labeling the red icon as “no sound” if the black icon is said to represent “sound.”

Icon 37

This icon shows a filled square inside an outline of a rounded rectangle. The square is in the center and appears to occupy the middle third of the rectangle.

This shape is one of the more interesting icons as it is open to interpretation. The icon looks similar to many things and could be an abstraction of many concepts. The icon may resemble a bandage, an eye, or a bowtie.

Color should greatly affect interpretation. This icon may inspire many ideas, but particular colors will narrow the possibilities. For example, if a

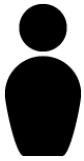
viewer sees this as a bandage or an eye, the person would be more likely to label it a bandage if it were orange. If green, it may more closely resemble an eye. It is predicted that color will greatly influence response.

Icon 38

This asymmetrical shape appears to have an organic shape at the end of a line. The shape appears to come to a point.

This is one of the few icons in the collection with asymmetry. The icon appears to lack balance and order, as there is both an organic shape and a slanted line. It may show movement, so it is predicted that most participants will identify an action or an object capable of performing an action. Expected responses are a match, a torch, a mop, and a paintbrush.

Color should be a factor. Most viewers would agree that this looks similar to a paintbrush. Color may not matter, as a paintbrush is capable of being any color. A torch or match may also be considered, but those options are usually reserved for warm colors like orange and red.



Icon 39

The shape consists of round and square edges. A filled circle sits just above a filled semicircle. Attached to the ends of the semicircle are two rounded lines that extend to the bottom of the icon. The ends of these lines are connected with a straight horizontal line. The complete shape is filled.

This is a common icon in many contexts such as buildings, computer programs, and technologies. This or a similar icon is used to represent a person. It could also be adapted to mean “user,” “male,” or “human.” This experiment will reveal how people label this icon without context. Some may give unconventional responses such as a bowling pin.

Color may affect interpretation in an expected manner revealed in color psychology research. However, contextual use may enhance

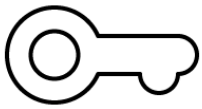
interpretation of color, making it more specific. For example, green generally means “good” and red “bad”. A participant may see the green icon as meaning “user is online” and red as being “offline.”

Icon 40

This icon is an empty circle with a bottom half of a vertical ellipse behind it.

This shape is simple and easily memorable. This may yield many responses, as the viewer may change the perspective or see it as part of a whole. Many will probably describe this as a necklace or locket. However, changing the perspective could make it look like a bird in flight, a top view of a dog’s snout, or a planet in orbit.

Color may invoke other ideas. If a participant would normally see this as a necklace if black and the icon is green, the viewer may decide to choose a response that makes sense for green. Of course, the standard color psychology principles should apply as well.



Icon 41

This shape is a complicated outline. It has one outline of a small circle that has a concentric larger circle surrounding it. The larger circle is cut where two horizontal lines extrude the shape. The upper line is longer and connects to a semicircle. The shorter line connects to a different semicircle that touches the former.

The icon is meant to resemble a key, particularly if the color is orange. If all viewers assume it is a key, they may give responses such as “unlock,” “lock,” “safe,” and “access.” Of course, all icons are open to interpretation, and users may suggest that it looks like something different.

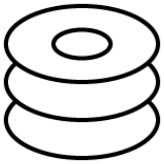
Color may be a factor in the usual way. It is expected that users will see this as a key, but color may cloud that interpretation. If the shape is green, a key might not be the first thought. Instead, it may look like a tree sideways, so “logging” is an expected response.

Icon 42

This icon consists of three identical arcs arranged vertically. The upper two face concave down, and the bottom concave up.

The shape may not resemble anything in particular to most users. It is merely an abstraction. After lengthy inspection, the participants may say it looks like an eye or waves but responses are expected to be varied and few.

Color should affect interpretation in the same manner as stated by color psychology research.



Icon 43

This icon is three overlapping identical ellipses. They are arranged vertically as if the upper covers part of the shape below. The top ellipse has a smaller concentric ellipse inside.

This symbol is meant to represent the hard drive on many computer systems. Most systems use a similar icon. It is expected that the technological participants will identify this as such. This is a test to see how understandable this icon is to generic computer users. The first impression for most may not be a hard drive, as few know what it looks like, and the shape seems to resemble more obvious figures. People may identify this as a stack of donuts or tires.

Color is expected to change the icon’s meaning in the same way as predicted by the research. Since people may struggle to think of an object that looks similar to the shape, the color may direct the viewer to choose an object that matches in hue.

Icon 44

The icon is a geometric shape with rigid edges and corners. The seven-sided polygon is flat on top and bends downward converging to a point.

This icon most likely will be seen as a lightning bolt. The interpretations may vary, as some may see it as lightning, others light, and some electricity. Though it is a common symbol, participants may have varying interpretations for what it represents such as pain or energy.

Colors may affect interpretation in the usual way since this icon will probably be identified by what it represents, not how it appears. A red icon may represent pain, and yellow lightning.

Icon 45

This symbol has a filled circle in the center. Concentric circles extend form the center. The upper and lower parts of the circle are removed.

The icon appears to have waves stemming from the center circle, as if it was producing them. Some may say it represents sound or light. However, this symbol may also appear in many places such as on a computer to represent Wi-Fi. Many variations of this logo exist. Instead of the viewers using imagination to decide what the icon represents, they may instead use recollection.

Varying colors may change interpretation, as this icon or similar ones are commonplace. An orange logo may remind the user of an RSS feed and blue may represent Wi-Fi. Of course, common color psychology could also affect interpretation, as a red icon may appear to indicate that Wi-Fi is off or non-functional.

Icon 46

This icon is a black circle. Inside this circle are five short line segments stemming from an area just outside the center. Each line is 45 degrees from the other, and each is placed on a diameter so that they would converge in the center.

Though this icon is meant to be abstract and represent nothing in particular, some participants may be able to identify this as something they have seen before. The shape may represent a cookie or flower or another object with rotational symmetry such as a hubcap or wheel. This icon is expected to yield numerous results, many of which are similar in number.

The color may affect interpretation, probably following the standard psychological principles of color.

Icon 47

This abstract icon is not meant to depict anything in particular. Two curves are mirrored, and the shape is tilted diagonally. The shape intercepts twice in the middle of the lines, causing the shape to continue after the intersection. Another curve attaches the two closed ends to each other.

Though this icon is not supposed to hold any particular meaning, it may represent many common shapes. As a whole, it may appear as a piece of candy in a wrapper. It may also represent a fish if an observer ignores either one of the ends. This icon is interesting because it may offer insight about how users remove certain parts of an icon in order to make sense of it. If dots are arranged in a circular pattern, and one dot is a noticeable outlier and seems out of place, the observer may decide to ignore the dot to simplify the image. In a sense, if the viewer sees a fish, the same principle applies.

Color may affect interpretation. If users note that this shape is either candy or a fish, the color may alter the decision. Blue or green, colors of

the sea, may encourage the viewer to see piscine shapes. Red or orange may look like candy.

Icon 48

This icon depicts a triangle below a horizontal rectangle. The top of the triangle just touches the center of the longer edge of the rectangle.

This is a common symbol in many disciplines. In litigation, it might represent the scales of justice. In physics, it may represent a lever. Either way, it is predicted that this icon might represent balance or a tool used in balancing. It was added to the library because of its illustrative properties and illusion of weight and predicted movement.

Color may not be as much of a factor for this icon as it is for others in this library. However, the addition of color might inspire the viewer to think of what else the icon could represent.

Icon 49

This abstraction is a filled isosceles triangle pointing rightward.

It is common in nature and may represent almost anything bearing a similar shape. It may most commonly be associated with a play button on a video or music player. This was added to the library because it is a common symbol used to carry a certain meaning, but with no context it is open to interpretation.

Since the icon is abstract and common, changing the color will most likely affect the viewer's interpretation. Most likely, the foundational psychology of color will take precedence in this interpretation such as the green arrow representing something positive and a red arrow having a negative connotation. It is predicted that this arrow will represent a play button, particularly when green.

Icon Grouping

Certain icons contain lines inside the completed shapes. These icons are #08, #09, #26, #27, #31, and #32.

Many icons are abstract and are not meant to represent anything in particular. The shapes are intended to be difficult to analyze. The icons from this library with similar properties are #03, #06, #40, #42, and #47.

Many icons are incredibly detailed and are meant to represent something specific. Though the interpretation may be varied, the shape itself is clear and recognizable. Some icons are even used in other systems. These icons are #01, #07, #12, #13, #20, #21, #22, #30, #39, #41, #43, #44, #48, and #49.

Some icons are simple shapes, yet they can convey meaning. Such icons are #02, #05, #12, #13, #20, #21, #24, #28, #29, and #49.

Special features such as arrows can affect the meaning of an icon. Lines can affect the interpretation as well, as they can represent a variety of effects such as smell, heat, and motion. The meanings of the features are usually intuitive and well known if used properly, and the psychological principles behind each attribute are supported by research. Icons that include these elements are #01, #04, #12, #15, #34, #36, #45, #48, and #49. Studying the response sets for icon #01, a simple arrow, may explain why participants interpreted other icons that included arrows a certain way.

Most icons in the library are symmetrical in some way. Asymmetrical icons are #07, #16, #34, #38, #41, and #44. Many icons in the library have rotational symmetry. These icons include #02, #03, #05, #06, #08, #09, #11, #12, #20, #21, #26, #27, #29, #32, #33, #37, #45, and #46.

Some icons seem to represent a series, as the picture contains an organized, reoccurring shape. The icons that seem to show a sequence are #02, #03, #10, #14, #27, #30, #42, and #43. Some icons, which have repeating shapes, seem to show that one is different from the others, as if to show a specific difference. These icons are #02, #03, #14, #37, #42, and #43.

Some icons in the library are round or contain a prominent circle that is a focal point for the symbol. These icons are #00, #02, #03, #09, #12, #14, #15, #25, #26, #29, and #46.

Specific icons in the library share intended commonalities with others. In many places, #12 and #13 are used, usually as conflicting symbols. Though these will be shown separately and in various colors, the interpretations may be antonyms of each other such as dark and light, or night and day, or may be in the same category such as brightness and contrast, or sun and moon. Icons #17, #18, and #19, are similar, as they are the same icon rotated. Icon #35 is similar to icon #18 in shape. Comparing the differences between these two response sets could show how much a small change in the shape will affect the interpretation. Icons #22, #23, and #24 are the same image with varying levels of detail. The icon represents a pencil, but as it loses detail, it becomes less obvious.

Screener

Before taking the survey, each participant completed a short questionnaire. They filled out their demographic profile, took a short colorblindness test, and agreed to take the test seriously. The responses were recorded with PHP session variables so they only needed to fill out the form once. When the browser closes, the variables erase. This prevents another user from signing on to the survey and taking the test under someone else's demographic information.

The screener consists of four demographic questions, a place to provide an email, the colorblindness test, and an agreement to the terms.

Pages

The home page is a gateway to the site. It introduces the participant to the survey and has links to pages with more information. The layout differs from other pages, containing a large logo and title in the middle of the screen. It promotes the incentive, inspiring users to take and complete the survey.

There are several pages that contain only text. These are not meant to be read my most participants but are present for those who wish to know more about the experiment or website. The About page discusses the purpose of the experiment and website. The Legitimacy Statement describes the measures taken to ensure the safety and privacy of the participant, links to RIT's IRB statement, and provides other text to show that the experiment is serious. Another page is an agreement to which the participant must consent, explaining that this is a legitimate scientific study and should be treated as such. It assures that their personal information will not be shared in any way that is related to their identity. It also notes the incentive and states that the participant is only eligible to receive it if he or she provides an active email address and reply with the

appropriate shipping information if he or she receives the notice they won. Another page is a short thanks to the users for their willingness to participate and notes the names of the faculty and staff that have made this experiment possible.

Before taking the survey, the user must answer a short series of questions. This is presented on a Screener page that collects age, gender, country of origin, and technical expertise. It will also prompt the user to enter an email and state that this field is not necessary to complete the survey. Below it is a statement explaining that if an email is not provided, the user cannot win the incentive. Below this is a checkbox that the reader will select indicating that he or she has read and agreed to the terms. It also asks whether the user is colorblind. Upon submitting, a JavaScript form validation function will run to ensure that all data entered is appropriate. If a field is missing an input, contains invalid characters, or, in the case of the Ishihara test, contains the incorrect response, it will generate a JavaScript Alert asking the users to fix the incorrect data. If the Ishihara test in completed incorrectly more than once, the users will be sent to a page explaining that they are not allowed to participate and their email may still be chosen for the incentive for their willingness to participate.

The user may complete two surveys: one that measures interpretation and the other that measures time needed to interpret. The former presents an icon to the user in the middle of the page. Below the icon is a text box and a submit button. A JavaScript focus function selects the box on page load. The user may enter the interpretation of the present image up to 100 characters. If the user writes 80 characters, a counter will appear below the input box stating how many characters remain. Upon completion of the form, the user may either press the submit button or press the enter key, both of which will reload the page, sending the necessary variables through to the next page using PHP. Upon loading the next page, the data will be sent to the database using PHP and MySQL. The next page will present a new random image. Each figure is presented randomly to erase the bias of presentation order. Each icon will show in one of the five colors randomly. The figures may show in any color but will only be presented once.

The latter survey shows a random image like in the first. However, each image shown must have enough votes in survey one to be effective. Before showing the image, the user is presented with four buttons that read the most popular descriptors of the image of a particular color. The user is given time to read them over, and then the image is displayed. When the image presents itself, a JavaScript timer begins. It counts in seconds until the user performs a mouse up action on a button. The timer stops and the page reloads. All necessary data is passed through to the next page, where it is stored in the database using PHP and MySQL.

A backend administrative tool will display the results of the survey in a clear and organized manner. This is not publicly accessible, as it requires login information known only to the people running the experiment. An ".htaccess" file protects access to this page, requiring user authorization before displaying it in a browser.

Files and Folders

The page "index.php" resides in the root directory and is responsible for the presentation and management of almost all web content. This page contains a series of PHP includes, each of which pull together the elements necessary to show the page. It places a footer and header on the page as well as a main content that is directed by the variable "loc" (short for location) in the URL.

The "images" folder contains all graphic elements on the site necessary for presentation. These visual enhancements are saved as JPEGs, GIFs, or PNGs and are optimized for the fastest loading time and best visual quality.

The "icons" folder contains all icons in the colors necessary for the experiment. Each element is saved as a number followed by a letter. The number represents the figure and the letter signifies which color it is. All icons are named as letters and numbers for simple programming, easy display, and discreet labeling.

The "includes" folder contains all pages for the site that are pulled together through the index.php page. These pages are the pieces of the site that are strung together to make a page.

The "css" folder contains the visual style rules for the site. The index.php page references the CSS to make page elements display in an aesthetically pleasing and readable format.

The "scripts" folder contains the JavaScript files necessary to dictate the performance of client-side functions.

The "phpMyAdmin" folder contains the files downloaded from PhpMyAdmin's website. This contains the database administration tool and allows for secure and quick data management.

Testing

A series of tests were conducted in multiple environments to ensure the proper function of the site. The tests included procedures for appearance, compatibility, and security. The site must maintain its view and style, work properly in any modern or common environment, and handle the exchange and maintenance of data in a reliable and stable manner.

This website has been tested on both Macintosh and PC. It has been viewed and tested in Mozilla Firefox 2.0 and 3.0 and Internet Explorer 5.0, 6.0, and 7.0. Numerous security tests have challenged the robustness of the site such as SQL injection, URL hacking, and other methods of hacking.

Ensuring Compatibility

The website is as cross-browser and cross-platform compatible as possible. The site is designed to work on virtually any browser and on any modern computer. The screen resolution accommodates screens with a minimum resolution of 600 pixels horizontal by 400 pixels vertical. Any larger size should be able to view the pages as intended. Users with the minimum monitor resolution will not need to use the scroll bar to take the quiz but may need to use it to read text-heavy pages.

The site is visible on monitors with very few colors. A 256 color palette or higher is required to read the fonts clearly and appropriately view the icon colors without pixilation. Almost no functioning computer has settings lower than this. Those that do are probably unable to connect to the Internet.

The site is tested on many modern browsers to ensure its functionality in each environment. The site has been tested and developed to work in Internet Explorer 6.0 and higher, Firefox 1.0 and higher, Safari, and Opera. Other browsers and versions may also run the site properly. The site will check which browser the user is running before showing the quiz. If the browser is incompatible, it will recommend newer browsers for the user to download.

No special plug-ins such as Java, Flash, or software updates are necessary to run this test, hastening the amount of time necessary to complete the survey. The browser will need to support session variables and be capable of running PHP, MySQL, XHTML, CSS, and JavaScript. All modern browsers should support these unless the user has modified the browser's initial settings, disabling its default capabilities.

All modern computers should support the website. It has been tested on Windows XP, Mac, and Vista. Display and functionality will most likely vary between operating systems. This site assumes that the user has the appropriate computer hardware to run such an application. This is not necessary to test. If the user can operate the Internet on the computer and the site loads, it should be able to run the survey part of the site.

The site's code is fully W3C compliant. The W3C, or World Wide Web Consortium, is the web standards committee in charge of establishing the rules and regulations for web programming (*World Wide Web Consortium*, 2008). Ensuring that the site meets its expectations will help ensure that future browsers and platforms will be able to run the site flawlessly. The W3C website has code validators that check a site's construction for errors. If an error is found, it will report the issue to the submitter and usually offer a brief note of how to correct it. If the validator finds no errors, it will display a message stating that the code is fully W3C compliant. If compliant, the code should load quicker and smoother and be more cross-browser and cross–platform compatible.

The code is written in a clear and concise manner. Wherever possible, reusable code such as headers, footers, and functions, are reused and included when necessary. The code is commented and formatted for readability and usability in case any changes or revisions are necessary. It is also formatted neatly so that other users will be able to understand it.

All images are developed and saved in a format that all browsers should be able to handle. The images are compressed and saved in a file format that will allow them to load quickly.

Security

In order to ensure the safety and security of the data, several measures were taken. The site must be secure to a reasonable extent. If the data is compromised, it will hinder the quality of the experiment and could cause data to be rearranged or lost. Participants who left their emails were told their contact information would not be shared. The site must protect against malicious or careless users and hackers. The site's robustness has been tested using common methods from various hack prevention sources.

One of the simplest hacking methods involves viewing the source code of a webpage (Andrews & Whittaker, 2006). Amateur web users are capable of viewing all the client-side code on a page. This can be seen within a few clicks in all common browsers. This tool is typically designed for developers and experts who may need access to a site's code. This reveals the underlying scripts

that present the website. It also shows code comments, reference URLs for images or other scripts, form metadata, referenced tools or applications, and any codes or passwords written in the text. It reveals how the site works. It is important to make sure that anything revealed in the code should not reveal any confidential information. This particular site was constructed with this practice in mind. Though the scaffolding of the site is visible, nothing revealed that visitors can use maliciously. The code that should not be seen is coded in PHP, which does not show when the user views the source. PHP passwords and MySQL database information is written in PHP and is not revealed to the user. Certain private information is essential for the code to communicate properly with database technologies and is hidden. In the Appendix, the passwords have been hidden for security purposes.

Direct traffic could also be an issue. A user can visit a page by typing the page's address in the URL bar (Andrews & Whittaker, 2006). In most cases, a user will visit a site by visiting a home page first. However, bookmarking, links, and URL guessing can take the user to a page inside a site without having to visit the site's home. Bookmarks and links take the user to a specific URL, showing a particular page inside a site. This could potentially cause problems on this survey's site, as it is important that the participant follow a certain series of pages. Many users understand the concept of guessing URLs. If a user is on a site whose address ends in pricing.html, and the user is searching for contact information but cannot find a link to it, that person might attempt to visit the page contact.html. If the page exists, the user will show at that page. If not, he or she will most likely receive an error stating that the page does not exist. Though this is helpful for many web surfers, it could cause problems on a site such as this one. The site's path is rigid: the user begins at the home page, visits the screener page, takes the survey, and then submits the data. Disturbing this path will make the survey function incorrectly. Data is passed from one page to the next, so it is important that all data be collected properly before submitting the data. Participants should not be able to access certain pages of the site directly. To prevent the users from visiting the incorrect pages, certain restricted pages test to see if a session variable has been set. It also checks to make sure that all necessary postdata are present. The preceding page would normally assign the proper postdata and session string to access the page. If the data is in place, the page will load, giving the user access. If any piece of the data is missing, the user will see an error page and then be sent to the home page. This prevents the user from accessing the pages in an inappropriate order.

Hackers can bypass form restrictions. Online forms usually have restrictions. For example, a text box might be restricted to only 10 characters (Andrews & Whittaker, 2006). This is usually set through defining an attribute of the HTML input tag. JavaScript can test to make sure the user has provided input and may restrict the use of certain characters. Form validation is a common

practice and seen on most websites that have forms. In this case, the user must provide certain information in required fields. The form has both HTML restrictions and JavaScript tests to make sure the form is completed properly. If the form such as the registration page contains errors, an error displays and the form data will not submit. The user is required to fix the form data and resubmit. Hackers can bypass user input on surveys and client-side validation. The form has been designed so that the JavaScript validation is reasonably robust. Though experienced hackers can probably modify the client-side forms, they cannot damage the database or compromise data. If a hacker had the desire to skip answering a question or provide an email address that contains blacklisted characters, it may be possible. However, the worst case scenario is probably the addition of incomplete data to the database. If such a case occurs, that participant's responses may be discarded. The email is simply a means of contact in case the participant wins the incentive prize. Providing an inaccurate or invalid email will cause the participant to lose the chance of winning. In summary, the site is difficult to hack but is still susceptible to attacks by the knowledgeable, malicious user. However, hacking these forms should not hinder the experiment or data.

Since the pages ensure the user follows a certain path using postdata and sessions, the site should also protect against modifying hidden fields and session hijacking (Andrews & Whittaker, 2006). Session variables can be hacked, which makes them vulnerable. The postdata from the forms are sent after being added to a hidden form field. Hidden fields can also be changed if the hacker has the skills. Since each page tests for certain variable values, the variables must contain data. Hackers may be able to change the data being submitted. However, the users have much control over the data itself, so hacking the system to insert any data of choice would not be worthwhile. Some hackers may attempt to insert contraband data such as SQL queries which contain invalid characters. The system checks for certain characters before submitting to ensure the data is pure and does not contain code that could potentially harm the system. If a hacker entered malicious data, the system still should not break.

SQL injection is the practice of writing SQL statements to be submitted to a database in an attempt to perform an action the site developers did not intend the user to do (Andrews & Whittaker, 2006). SQL injection is among the most dangerous hacks for websites with databases. It is even more of a threat to sites that contain user's personal information such as bank account numbers and addresses. This is serious, especially for sites that guarantee that the user's information will be kept confidential. Aside from compromising privacy, SQL injection also allows hackers to modify and delete data stored in a secure database.

To ensure this would not happen on iconstudy, database information exchanges were kept to a minimum (Andrews & Whittaker, 2006). Aside from using them only where necessary, the data was stored in databases managed by PhpMyAdmin, a free online database management system. This reputable technology protects and preserves data. However, this does not prevent hackers from working through system holes to compromise the data. The input boxes on the site check for invalid characters. This blacklist contains many characters that are necessary for execution of SQL injection. Identifying these characters and removing them helps prevent the submission of inappropriate input.

Overall, the system is robust. It protects against all tested client-side and server-side hacks and provides a low risk to data (Andrews & Whittaker, 2006). Data will frequently be copied for easy recovery in case data is lost or compromised. Also, the site is at minimal risk, as research sites are typically not a target for hackers. Sites that handle financial information or transfer secretive or coveted information are at risk, as hackers choose to invest the time and energy in breaking such sites. There is not much of interest in a research site.

Compact Disc

The attached compact disc contains all digital materials for this experiment. The following files are on the CD:

- Data Directory – Includes Microsoft Excel files of both raw and modified data and SQL dumps of both databases used in this thesis.
- Graphs Directory – Contains the visual representations of the response frequencies after refining the reponses.
- Icons Directory – Contains all icon figures in every possible color for this thesis as well as an Adobe Illustrator file containing the original vector shapes for each icon.
- IconStudy.com Website Files Directory – Contains all files necessary to run the survey except for the database backend.
- A link to www.iconstudy.com.
- A PDF of this report.

Appendix B – Source Code and Pseudo Code

Index.php Script

```
1.  <?php
2.          $v_DBHostName="localhost";
3.          $v_DBUserName="bdparker_brendan";
4.          $v_DBPassword="deutsch";
5.
6.          session_name('iconstudyAccess');
7.          session_start();
8.  ?>
9.
10. <!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
    "http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
11. <html xmlns="http://www.w3.org/1999/xhtml" xml:lang="en" lang="en">
12.
13. <head>
14.
15. <link href="css/main.css" rel="stylesheet" type="text/css" />
16. <link rel="shortcut icon" href="images/favicon/favicon.ico" />
17. <meta name="description" content="A fun icon identification survey where you
    describe signs and symbols. You can win a $15 gift certificate to Barnes and Noble
    for participating." />
18. <meta name="rating" content="General" />
19. <meta name="robots" content="Index, follow" />
20. <meta name="resource-type" content="document" />
21. <meta http-equiv="keywords" content="about, ann haake, anne haake, bdparker,
    bdparker.com, brendan, brendan d parker, building, but, call, calls, capstone,
    capstone project, capstone projects, capstone proposal, capstone topics, career,
    chi, civil engineering, clinic, college symbols, colleges, computer, computer
    engineering, computer experiment, computer human interfaces, computer meanings,
    computer project, computer sciecne, computer software, computer thesis, computers,
    construction, course project, cv, data interaction, data interpretation, david,
    degree project, describe, design, design engineering, design rit, designing
    interface, desktops, dianne bills, diary, dissertation, dissertation editing,
    dissertation help, dissertation ideas, dissertations, doctor, doctors, dr, dreams,
    engineer, engineering, engineering experiment, engineering jobs, engineering
    psychology, environmental experiment, environmental sciecne, experiment,
    experiment ideas, experiment jobs, experiment materials, experiment process,
    experiment project, experiment projects, experiment proposal, experiment science
    fair, experiment topics, experiments, framing, friend, friends, fun, fun data,
    graph, graphic data, graphic design, graphic symbol, graphics, graphs, gui design,
    hci, hci application, hci computer, hci course, hci courses, hci data, hci
```

degrees, hci education, hci examples, hci gui, hci guidelines, hci human, hci institute, hci interaction, hci interactive, hci interface, hci issues, hci journal, hci masters, hci methods, hci new york, hci paper, hci programs, hci schemes, hci studies, hci study, hci techniques, hci ui, hci usability, hci-chi, help, human computer, human computer interaction, human computer interaction technology, human computer interface, human computer interface hci, human computing, human ergonomics, human factors hci, human interaction, human interfaces, human usability, human user interface, human-computer, human-computer interaction institute, human-computer interface, humans, i, i thought, i you, i your, icon, icon symbol, icon symbols, icons, iconstudy, ideas, if, image, images, imagine, industrial project, industry project, innovation, innovative, innovative meaning, interaction, interaction design, interaction graph, interaction interpretation, interactive meaning, interface, interface design, interface interaction, internal medicine, interpret, interpret meaning, interpret research, interpretation, interpretations, interpreting, intuitive, investigate, investigations, investigator, investigators, journals, knew, know, laptop, laptops, letter, light bulb, lightbulb, like thought, master thesis, master's, masters thesis, materials sciecne, me, meaning data, meaning symbols, mechanical engineer, mechanical engineering, mechanical project, medical, medicine, methodology, monitors, ms project, multimedia interaction, my, my call, new technology, new york, new york rit, new york university, news, notebook, notebooks, now, ntid, ntid college, online engineering degree, online interpret, online journal, own, parker, pcs, pc's, people, personality, photo, pic, pictures, process, program, project, project control, project courses, project design, project engineer, project ideas, project manufacturing, project materials, project programs, project proposal, project software, project studies, project study, project technology, project topics, project work, projects, proposal, psychiatry, psychoanalysis, psychologist, psychologists, psychology, quiz, quizs, quizzes, research, research project, resume thesis, rit, rit - rochester, rit college, rit courses, rit data, rit hci, rit institute, rit masters, rit online, rit programs, rit psychology, rit research, rit survey, rit technology, rob parody, robert parody, rochester, rochester courses, rochester environmental, rochester institute of technology, rochester jobs, rochester ny technology, rochester professor, rochester project, rochester resume, rochester science, rochester technology, sciecne jobs, sciecne project, sciecne projects, science, science experiment, science fair thesis, science project, science project ideas, science project topics, science projects, science projects com, science projects ideas, sees, senior capstone, senior project, senior thesis, shape, shape meanings, shapes, student project, student-experiment, students project, study technology, survey, survey online, survey research, symbol, symbol interpretation, symbols, symbols graphic, symbols new york, technical project, technical thesis, technology, technology experiment, technology meaning, technology meanings, technology symbols, theses, thesis, thesis construction, thesis course, thesis help, thesis paper, thesis papers, thesis professor, thesis project, thesis proposal, thesis research, thesis science, thesis statement, thesis technology, thesis topics, thesis writing, thought, thought about, thought me, thoughts, topics, trivia, ui design, universities, usability, usability evaluation, usability interface, usability testing, user centered design, user experience, user interface, user

```
interface design, user interface interaction, web design, work, work experiment,
write, write someone, write you, writes, writing, you" />
22. <meta name="keywords" content="about, ann haake, anne haake, bdparker,
bdparker.com, brendan, brendan d parker, building, but, call, calls, capstone,
capstone project, capstone projects, capstone proposal, capstone topics, career,
chi, civil engineering, clinic, college symbols, colleges, computer, computer
engineering, computer experiment, computer human interfaces, computer meanings,
computer project, computer sciecne, computer software, computer thesis, computers,
construction, course project, cv, data interaction, data interpretation, david,
degree project, describe, design, design engineering, design rit, designing
interface, desktops, dianne bills, diary, dissertation, dissertation editing,
dissertation help, dissertation ideas, dissertations, doctor, doctors, dr, dreams,
engineer, engineering, engineering experiment, engineering jobs, engineering
psychology, environmental experiment, environmental sciecne, experiment,
experiment ideas, experiment jobs, experiment materials, experiment process,
experiment project, experiment projects, experiment proposal, experiment science
fair, experiment topics, experiments, framing, friend, friends, fun, fun data,
graph, graphic data, graphic design, graphic symbol, graphics, graphs, gui design,
hci, hci application, hci computer, hci course, hci courses, hci data, hci
degrees, hci education, hci examples, hci gui, hci guidelines, hci human, hci
institute, hci interaction, hci interactive, hci interface, hci issues, hci
journal, hci masters, hci methods, hci new york, hci paper, hci programs, hci
schemes, hci studies, hci study, hci techniques, hci ui, hci usability, hci-chi,
help, human computer, human computer interaction, human computer interaction
technology, human computer interface, human computer interface hci, human
computing, human ergonomics, human factors hci, human interaction, human
interfaces, human usability, human user interface, human-computer, human-computer
interaction institute, human-computer interface, humans, i, i thought, i you, i
your, icon, icon symbol, icon symbols, icons, iconstudy, ideas, if, image, images,
imagine, industrial project, industry project, innovation, innovative, innovative
meaning, interaction, interaction design, interaction graph, interaction
interpretation, interactive meaning, interface, interface design, interface
interaction, internal medicine, interpret, interpret meaning, interpret research,
interpretation, interpretations, interpreting, intuitive, investigate,
investigations, investigator, investigators, journals, knew, know, laptop,
laptops, letter, light bulb, lightbulb, like thought, master thesis, master's,
masters thesis, materials sciecne, me, meaning data, meaning symbols, mechanical
engineer, mechanical engineering, mechanical project, medical, medicine,
methodology, monitors, ms project, multimedia interaction, my, my call, new
technology, new york, new york rit, new york university, news, notebook,
notebooks, now, ntid, ntid college, online engineering degree, online interpret,
online journal, own, parker, pcs, pc's, people, personality, photo, pic, pictures,
process, program, project, project control, project courses, project design,
project engineer, project ideas, project manufacturing, project materials, project
programs, project proposal, project software, project studies, project study,
project technology, project topics, project work, projects, proposal, psychiatry,
psychoanalysis, psychologist, psychologists, psychology, quiz, quizs, quizzes,
```

```
        research, research project, resume thesis, rit, rit - rochester, rit college, rit
        courses, rit data, rit hci, rit institute, rit masters, rit online, rit programs,
        rit psychology, rit research, rit survey, rit technology, rob parody, robert
        parody, rochester, rochester courses, rochester environmental, rochester institute
        of technology, rochester jobs, rochester ny technology, rochester professor,
        rochester project, rochester resume, rochester science, rochester technology,
        sciecne jobs, sciecne project, sciecne projects, science, science experiment,
        science fair thesis, science project, science project ideas, science project
        topics, science projects, science projects com, science projects ideas, sees,
        senior capstone, senior project, senior thesis, shape, shape meanings, shapes,
        student project, student-experiment, students project, study technology, survey,
        survey online, survey research, symbol, symbol interpretation, symbols, symbols
        graphic, symbols new york, technical project, technical thesis, technology,
        technology experiment, technology meaning, technology meanings, technology
        symbols, theses, thesis, thesis construction, thesis course, thesis help, thesis
        paper, thesis papers, thesis professor, thesis project, thesis proposal, thesis
        research, thesis science, thesis statement, thesis technology, thesis topics,
        thesis writing, thought, thought about, thought me, thoughts, topics, trivia, ui
        design, universities, usability, usability evaluation, usability interface,
        usability testing, user centered design, user experience, user interface, user
        interface design, user interface interaction, web design, work, work experiment,
        write, write someone, write you, writes, writing, you" />
23.     <meta http-equiv="Content-Language" content="en-us" />
24.     <meta http-equiv="content-type" content="text/html; charset=iso-8859-1" />
25.     <base target="_self" />
26.     <meta name="copyright" content="Brendan Parker (2009)" />
27.
28.     <title>Icon Study</title>
29.
30.     </head>
31.
32.     <?php
33.     if (isset($_SERVER['HTTP_USER_AGENT']) && strpos($_SERVER['HTTP_USER_AGENT'],
        'MSIE') !== false){
34.         ?> <body<?php if ($_GET['loc'] != "" && $_GET['loc'] != "index"){ echo '
        class="backgroundHeaderIE"'; } ?>> <?php
35.     } else {
36.         ?> <body<?php if ($_GET['loc'] != "" && $_GET['loc'] != "index"){ echo '
        class="backgroundHeader"'; } ?>> <?php
37.     } ?>
38.
39.     <?php
40.             if ($_GET['loc'] == "" || $_GET['loc'] == "index"){  include
        'includes/home.inc';          }
```

```
41.         if ($_GET['loc'] == "survey"){
            include 'includes/survey.inc';              }
42.         if ($_GET['loc'] == "register"){                                    include
    'includes/register.inc';      }
43.         if ($_GET['loc'] == "about"){                                       include
    'includes/about.inc';         }
44.         if ($_GET['loc'] == "instructions"){                        include
    'includes/instructions.inc';}
45.         if ($_GET['loc'] == "analysis"){                                    include
    'includes/analysis.inc';      }
46.         if ($_GET['loc'] == "submit"){
            include 'includes/submit.inc';              }
47.         if ($_GET['loc'] == "sendmail"){                                    include
    'includes/sendmail.inc';      }
48.   ?>
49.
50.   <script type="text/javascript">
51.         var gaJsHost = (("https:" == document.location.protocol) ? "https://ssl."
    : "http://www.");
52.         document.write(unescape("%3Cscript src='" + gaJsHost + "google-
    analytics.com/ga.js' type='text/javascript'%3E%3C/script%3E"));
53.   </script>
54.
55.   <script type="text/javascript">
56.         try {
57.                 var pageTracker = _gat._getTracker("UA-9245498-1");
58.                 pageTracker._trackPageview();
59.         } catch(err) {}
60.   </script>
61.
62.   </body>
63.
64.   </html>
```

Index.php Annotated

1. Begin PHP code
2. Create variable ‘$v_DBHostName’ and initially set to “localhost” for database settings
3. Create variable ‘$v_DBUserName’ and initially set to “**********” (database name has been removed for security purposes)
4. Create variable ‘$v_ DBPassword’ and initially set to “*******” (password has been removed for security purposes)

5. Blank line
6. Set the session name to 'ionstudyAccess'
7. Begin the session
8. End PHP code
9. Blank Line
10. Set DOCTYPE to XHTML 1.0 Transitional based on W3.org standards
11. Begin HTML code
12. Blank line
13. Begin HEAD tag to contain metadata
14. Blank line
15. Reference external CSS stylesheet 'main.css'
16. Reference favicon to display in URL bar of participating browsers
17. Set META variable 'description' which summarizes the site's purpose and displays in search engines
18. Set META variable 'general' to show that the site's content is appropriate for all audiences
19. Set META variable 'robots' to allow search engines to crawl site
20. Set META variable 'resource-type' which states this page is a document
21. Set META variable 'keywords' for search engine optimization using 'http-equiv'
22. Set META variable 'keywords' for search engine optimization using 'name'
23. Set META variable 'Content-Language' as 'en-us' which states the site is written in American English
24. Set META variable 'content-type' to use character set 'iso-8859-1', a default set recognized by most browsers in the United States
25. Set BASE to self so all linked pages open in the same window
26. Set META variable 'copyright' to show ownership and copyright information for the site and materials within the site
27. Blank line
28. Begin TITLE and end TITLE to set the title and display text "Icon Study" in browser's header
29. Blank line
30. End HEAD tag
31. Blank line
32. Begin PHP code
33. Begin IF statement to determine if browser is Internet Explorer
34. End PHP code, begin BODY tag, and include class 'backgroundHeaderIE' to BODY if the page is not the home page using PHP
35. End IF statement and begin ELSE statement
36. End PHP code, begin BODY tag, and include class 'backgroundHeader' to BODY if the page is not the home page using PHP
37. End ELSE statement and end PHP code
38. Blank line
39. Begin PHP code

```
40.  If GET variable 'loc' equals "index" or an empty string, include 'home.inc'
41.  If GET variable 'loc' equals "survey", include 'survey.inc'
42.  If GET variable 'loc' equals "register", include 'register.inc'
43.  If GET variable 'loc' equals "about", include 'about.inc'
44.  If GET variable 'loc' equals "instructions", include 'instructions.inc'
45.  If GET variable 'loc' equals "analysis", include 'analysis.inc'
46.  If GET variable 'loc' equals "submit", include 'submit.inc'
47.  If GET variable 'loc' equals "sendmail", include 'sendmail.inc'
48.  End PHP code
49.  Blank line
50.  Code provided by Google Analytics for visitor tracking
51.  Code provided by Google Analytics for visitor tracking
52.  Code provided by Google Analytics for visitor tracking
53.  Code provided by Google Analytics for visitor tracking
54.  Blank line
55.  Code provided by Google Analytics for visitor tracking
56.  Code provided by Google Analytics for visitor tracking
57.  Code provided by Google Analytics for visitor tracking
58.  Code provided by Google Analytics for visitor tracking
59.  Code provided by Google Analytics for visitor tracking
60.  Code provided by Google Analytics for visitor tracking
61.  Blank line
62.  End BODY tag
63.  Blank line
64.  End HTML code
```

About.inc Script

```
1.  <?php
2.  include 'includes/header.inc';
3.  ?>
4.
5.  <div class="header">About</div>
6.
7.  <div class="content">
8.
9.  <p>The purpose of this survey is to further understand how people interpret icons
    and visual symbols.</p>
10. <p>Have you ever seen a symbol and were not sure what it meant? Perhaps you have
    seen some on road signs, in books, on signs in buildings, and on the computer.
    Unclear symbols are all around us. They can cause problems in many operations.
    Clear and intuitive symbols help improve the usability of any system.</p>
```

```
11.  <p>Usability is the study of how people interact with interfaces, both tangible
     and on a computer screen. Icons are important tools for expressing the functions
     of certain parts of the interface. They assist in the communication between the
     human and the interface. Icons are a universal language, interpretable by people
     from all cultures and backgrounds. </p>
12.  <p>Though icons are an important and effective means of communication between a
     user and interface, they must be appropriately designed to function as they
     should. Many icons are ambiguous, causing confusion and miscommunication.</p>
13.  <p>This online survey is a fun an effective way to gather enough data to learn
     more about how people interpret icons. In this survey, you will provide your
     opinions of what the icons shown represent. There are no correct or incorrect
     responses.</p>
14.  <p>At the end, we will analyze all the data the survey has collected. Our goal is
     to provide enough insight to improve the effectiveness and clarity of icons and
     visual symbols. Improving the usability of any system will promote a more stress-
     free and efficient environment.</p>
15.  <p>If you complete the survey, you will also be eligible to win a $15 gift
     certificate to Barnes and Noble Booksellers. Before you start, you will have the
     opportunity to provide us your email. You must provide your email to have a chance
     to win our raffle. If you are selected as the winner, you will receive a message
     asking for a mailing address where we can send the certificate.</p>
16.
17.  <?php
18.  include 'includes/footer.inc';
19.  ?>
20.
21.  </div>
```

About.inc Annotated

```
1.   Begin PHP code
2.   Include ‘header.inc’ to draw a header on the page
3.   End PHP code
4.   Blank line
5.   Add the page title to the top of the page
6.   Blank line
7.   Begin div which holds primary content
8.   Blank line
9.   Add a paragraph to display text
10.  Add a paragraph to display text
11.  Add a paragraph to display text
12.  Add a paragraph to display text
13.  Add a paragraph to display text
```

14. Add a paragraph to display text
15. Add a paragraph to display text
16. Blank line
17. Begin PHP code
18. Include 'footer.inc' to draw a footer on the page
19. End PHP code
20. Blank line
21. End DIV tag

Badpage.inc Script

```
1.  <div class='header'>This page is not accessible</div><div class='content'>
2.  <div id='mainPanel' style='align: center; text-align: center;'>
3.  <br /><br />
4.  This page is not accessible. You must start the survey from the beginning.<br
    /><br />
5.  If you were in the middle of the survey, your progress has been lost.<br /><br />
6.  To complete the survey and serve as a participant in this study, click the link
    below:<br /><br />
7.  <a href='http://www.iconstudy.com/'>http://www.iconstudy.com/</a>
8.  </div>
9.  </div>
10.
11. <script type="text/javascript" language="javascript">
12.         setTimeout("window.location = 'http://www.iconstudy.com';", 1000);
13. </script>
```

Badpage.inc Annotation

1. Add the page title to the top of the page
2. Begin DIV which contains page content
3. Add two line breaks for spacing
4. Add display text and two line breaks
5. Add display text and two line breaks
6. Add display text and two line breaks
7. Add a link to iconstudy.com
8. End div tag
9. End div tag
10. Blank line
11. Begin JavaScript code
12. Set a timeout to return the user to the home page after 1 second
13. End JavaScript code

Footer.inc Script

```
1.  <div class="footer">
2.
3.  Copyright &copy; Brendan Parker, <?=date("Y")?> - <a href="http://www.rit.edu"
    target="_blank">Rochester Institute of Technology</a><br />
4.  Rochester, New York - United States of America
5.  <br /><br />
6.
7.  </div>
```

Footer.inc Annotation

```
1.  Begin div to frame and position footer
2.  Blank line
3.  Copyright text with automatic Copyright date and link to rit.edu which opens in a
    new window
4.  Add text line
5.  Add two line breaks
6.  Blank line
7.  End div tag
```

Header.inc Script

```
1.  <div class="topBar"></div>
2.
3.  <div class="title"></div>
4.  <div class="topNav">
5.
6.  <a
    onclick="window.open('docs/about.html','Consent_Form','scrollbars=auto,height=450,
    width=550,resizable');" style="text-decoration: underline;">About</a>
     | 
7.  <a href="http://www.rit.edu" target="_blank">RIT Home</a>  | 
8.  <a href="mailto:info@iconstudy.com">info@iconstudy.com</a>
9.
10. <?php
11. if ($_GET['loc'] == "survey"){
12. ?>
13.   |  <a onclick="counter=60; testForEnd();"><span style="color: #111111;
    font-weight: bold;">Quit</span></a>
14. <?php
15. }
16. ?>
```

```
17.
18.    </div>
```

Header.inc Annotation

```
1.     Add div to display heading format
2.     Blank line
3.     Add div to display page logo
4.     Begin div which displays heading navigation
5.     Blank line
6.     Make link to 'about.inc' which opens in a new window using JavaScript
7.     Make link to rit.edu which opens in a new window
8.     Add email link which opens mail with info@iconstudy.com as recipient when clicked
9.     Blank line
10.    Begin PHP code
11.    Begin IF statement to test if GETDATA 'loc' equals 'survey', running the code only
       if the user is on the survey page
12.    End PHP code
13.    Add JavaScript code which presents "Quit" button when clicked which works by
       setting the counter to 60 then running the function 'testForEnd'
14.    Begin PHP code
15.    End IF statement
16.    End PHP code
17.    Blank line
18.    End div tag
```

Home.inc Script

```
1.     <div class="mainSeeDescribeSubmit" title="IconStudy.com - Testing Icon Usability
       and Cognitive Psychology. See it, describe it, submit it! This survey tests
       principles in psychology, usability, computing, and graphic design."></div>
2.     <div class="mainTitle"></div>
3.     <div class="mainLogo" title="IconStudy.com - Testing Icon Usability and Cognitive
       Psychology"></div>
4.     <div class="win15" onclick="window.location='#bn';"></div>
5.
6.     <div class="mainHeader">
7.     <a href="index.php?loc=register"><img style="margin-top: 30px;"
       src="images/begin.gif" alt="Start the Survey!"
       onmouseover="this.src='images/begin_over.gif';"
       onmouseout="this.src='images/begin.gif';" border="0" /></a>
8.     <br />
9.     <a href="index.php?loc=instructions"><img style="margin-top: 4px; margin-bottom:
       10px;"" src="images/instructions.gif" alt="Instructions"
```

```
onmouseover="this.src='images/instructions_over.gif';"
onmouseout="this.src='images/instructions.gif';" border="0" /></a>
<br />
<p><b>Here's how it works:</b> You will complete a short questionnaire so we can know some important facts about you. It will also let us know if you are eligible to take the survey.</p>
<p>Next, we will show you a series of icons. You will be asked to type what you think the icon represents. You may submit as many answers as you wish. There are no right or wrong responses. There are 50 icons, and the survey should take about 10 to 15 minutes. Questions? Email us at <a href="mailto:info@iconstudy.com">info@iconstudy.com</a></p>
<br />

<div style="clear: both; border-top: solid 2px #AAAAAA;">
        <div style="position: relative; width: 280px; float:left; margin-right: 20px; background-color: #FFFFFF;">
        <h2 style="color: #1FB410;">Win a $15 Barnes and Noble Gift Certificate!</h2>
        <p>We are giving away 6 certificates to participants. If you take our survey, you will be automatically entered in the drawing. Winners will receive an email from iconstudy.com after the study concludes. The cards are usable in-store and online at <a href="http://www.barnesandnoble.com/" target="_blank">www.barnesandnoble.com</a></p>
        <p>The first drawing is scheduled for <b>July 10, 2009</b>.</p>
        <a name="bn"></a>
        <a href="http://www.barnesandnoble.com/" target="_blank"><img src="images/bn.gif" alt="Win a Barnes and Noble Gift Certificate worth $15!" border="0" /></a>
        </div>
        <div style="position: relative; width: 280px; float:left; margin-left: 20px;">
                <h2>Send this survey to others</h2>
                <form name="emailForm" action="index.php?loc=sendmail" method="post">
                Your name or email:<br />
                <input type="text" class="emailFormNameBox" name="name" /><br /><br />
                Type the recipient email addresses below, separating each one with a comma:<br />
                <textarea name="email" class="emailFormAddressBox" rows="" cols=""></textarea>
                <br /><br />
                Include a brief message:<br />
                <textarea name="message" class="emailFormMessageBox" rows="" cols=""></textarea>
```

```
33.                 <br />
34.                 <input type="submit" class="emailFormSend" value="Send" />
35.                 <br /><br />
36.                 </form>
37.           </div>
38.    </div>
39.
40.    <?php
41.    include 'includes/footer.inc';
42.    ?>
43.
44.    </div>
```

Home.inc Annotation

1. Add div to display slogan at top of page with title script for search engine optimization
2. Add div to display the title
3. Add div to display the main logo at with title script for search engine optimization
4. Add div to display incentive at top of page which takes user to anchor "#bn" when clicked
5. Blank line
6. Begin div which contains and formats the header for the home page
7. Add "Begin" button with JavaScript rollover effect which changes the page to 'register' when clicked
8. Add line break
9. Add "Instructions" button with JavaScript rollover effect which changes the page to 'instructions' when clicked
10. Add line break
11. Add paragraph of text with some bolded text
12. Add paragraph of text and an email hyperlink
13. Add line break
14. Blank line
15. Begin div to format content at page bottom
16. Begin div to format content at page bottom on left
17. Add level 2 header tag
18. Add paragraph of text and hyperlink
19. Add paragraph of text with some bolded text
20. Add anchor "#bn"
21. Add hyperlinked image to barnesandnoble.com
22. End div tag
23. Begin div to format content at page bottom on left

```
24.  Add level 2 header tag
25.  Begin form which opens the 'sendmail' page upon submission
26.  Add text and line break
27.  Add input box for name and two line breaks
28.  Add text and line break
29.  Add text area input box for emails
30.  Add two line breaks
31.  Add text and line break
32.  Add text area input box for a message and two line breaks
33.  Add line break
34.  Add submit button which opens the 'sendmail' page upon submission
35.  Add two line breaks
36.  End form tag
37.  End div tag
38.  End div tag
39.  Blank line
40.  Begin PHP code
41.  Include 'footer.inc' to display footer content
42.  End PHP code
43.  Blank line
44.  End div tag
```

Instructions.inc Script

```
1.   <?php
2.   include 'includes/header.inc';
3.   ?>
4.
5.   <div class="header">Instructions</div>
6.
7.   <div class="content">
8.
9.   <div style="text-align: center;">
10.  <img src="images/instruction_panel.gif" alt="Instructions for the Icon Study
     Survey" style="border: solid 1px #555555;" />
11.  </div>
12.
13.  <ul>
14.  <li>When you start the survey, an <span class="vocab">icon</span> will
     appear.</li>
15.  <li>On the right is a <span class="vocab">box</span> in which you will write what
     you believe the <span class="vocab">icon</span> represents. After you <span
     class="vocab">write a word or phrase</span> in the box, click the <span
```

```
        class="vocab">"+" button</span> or press the <span class="vocab">Enter (or Return)
        key</span> on your keyboard. This will add your answer to your <span
        class="vocab">list</span>.</li>
16.     <li>Your answer will show in the large <span class="vocab">response box</span>.
        The <span class="vocab">response box</span> lists all your answers. If you want to
        remove a submitted response, press the <span class="vocab">Erase</span> button
        adjacent to the response to remove that response.</li>
17.     <li>You may submit as many responses as you would like. When you feel you have
        added enough, press the <span class="vocab">Finish button</span> or press the
        <span class="vocab">Enter (or Return) key</span> on your keyboard twice
        quickly.</li>
18.     <li>When you press <span class="vocab">finish</span>, your responses will clear.
        New <span class="vocab">icons</span> will appear until you have completed the
        study. The <span class="vocab">Progress Bar</span> at the top of the screen shows
        how close you are to finishing the survey.</li>
19.     <li>You will need to fill out a short questionnaire beforehand so we know more
        about you. <a href="index.php?loc=register">Click here to start the
        survey.</a></li>
20.     </ul>
21.
22.     <?php
23.     include 'includes/footer.inc';
24.     ?>
25.
26.     </div>
```

Instructions.inc Annotation

```
1.      Begin PHP code
2.      Include ‘header.inc’ to draw a header on the page
3.      End PHP code
4.      Blank line
5.      Add the page title to the top of the page
6.      Blank line
7.      Begin div which holds primary content
8.      Blank line
9.      Begin div to center elements
10.     Add instruction image
11.     End div tag
12.     Blank line
13.     Begin unordered list
14.     Add list element
15.     Add list element
16.     Add list element
```

```
17.   Add list element
18.   Add list element
19.   Add list element
20.   End unordered list
21.   Blank line
22.   Begin PHP code
23.   Include 'footer.inc' to draw a footer on the page
24.   End PHP code
25.   Blank line
26.   End DIV tag
```

Register.inc Script

```
1.    <?php
2.    include 'includes/header.inc';
3.    ?>
4.
5.    <?php $_SESSION['SessionWhere'] = "register"; ?>
6.
7.    <div class="header">Screener Survey</div>
8.
9.    <div class="content">
10.   <p>Thank you very much for agreeing to participate.</p>
11.   <p>You will first need to share some personal information. This will help us
      analyze the results after we gather enough data. We will not disclose any of your
      responses in a way that will be associated with your identity.</p>
12.   <p>Please acknowledge that this is a scientific study and should be treated as
      such. This experiment has been developed by a Master's student at the Rochester
      Institute of Technology. The data collected in this experiment will be used for
      completion of a Master's capstone thesis.</p>
13.
14.   <br /><br />
15.
16.   <script type="text/javascript" language="javascript">
17.   //<![CDATA[
18.
19.   function checkForm(){
20.           var q0checked = 1;
21.           var q1checked = 1;
22.           var q2checked = 1;
23.           var q3checked = 1;
24.           var q4checked = 1;
25.           var q7checked = 1;
```

```
26.          var q8checked = 1;
27.          var emailchecked = 0;
28.          var endMessage = "";
29.
30.          if (document.getElementById('q0').checked){
31.                 q0checked = 0;
32.          }
33.          if (document.getElementById('q1').checked){
34.                 q1checked = 0;
35.          }
36.          for (var i=0; i < document.screenerForm.age.length; i++){
37.                 if (document.screenerForm.age[i].checked) {
38.                        q2checked = 0;
39.                 }
40.          }
41.          for (var i=0; i < document.screenerForm.gender.length; i++){
42.                 if (document.screenerForm.gender[i].checked) {
43.                        q3checked = 0;
44.                 }
45.          }
46.          for (var i=0; i < document.screenerForm.experience.length; i++){
47.                 if (document.screenerForm.experience[i].checked) {
48.                        q4checked = 0;
49.                 }
50.          }
51.          if (document.getElementById('q7').checked){
52.                 q7checked = 0;
53.          }
54.          for (var i=0; i < document.screenerForm.colorblind.length; i++){
55.                 if (document.screenerForm.colorblind[i].checked) {
56.                        q8checked = 0;
57.                 }
58.          }
59.          var characterBlacklist = new
     Array("<",">","/","\\","{","}","[","]","`","~","?",",",":",";","|","+","=","!","#"
     ,"$","%","^","&","*","(",")");
60.          var thisString = document.getElementById('emailForm').value;
61.          var badcharacters = "";
62.
63.          if (thisString.length > 0){
64.                 for (var i = 0; i < characterBlacklist.length; i++){
65.                        for (var j = 0; j < thisString.length; j++){
```

```
66.                                 if (characterBlacklist[i] == thisString.charAt(j)){
67.                                         emailchecked = 1;
68.                                         badcharacters += characterBlacklist[i]+" ";
69.                                 }
70.                         }
71.                 }
72.         }
73.
74.         endMessage += '<div class="formSet"><div
    class="formQuestion"> </div><div class="formResponseError"><b>You did not
    complete some of the above fields:</b><br />';
75.         if (q0checked == 1){endMessage += "<br />You did not certify that this is
    your first time taking this survey.";}
76.         if (q1checked == 1){endMessage += "<br />You did not certify that you are
    over 18.";}
77.         if (q2checked == 1){endMessage += "<br />You did not specify an age.";}
78.         if (q3checked == 1){endMessage += "<br />You did not specify your
    gender.";}
79.         if (q4checked == 1){endMessage += "<br />You did not estimate your
    technical experience.";}
80.         if (q7checked == 1){endMessage += "<br />You did not agree to the consent
    form.";}
81.         if (q8checked == 1){endMessage += "<br />You did not specify whether you
    were colorblind.";}
82.         if (emailchecked == 1){endMessage += "<br />Your email address contains
    invalid characters. ( "+badcharacters+")";}
83.         if (q1checked == 1 || q2checked == 1 || q2checked == 1 || q3checked == 1
    || q4checked == 1 || q7checked == 1 || q8checked == 1 || emailchecked == 1){
84.                 endMessage += '<span id="errorReport"></span></div></div>';
85.                 document.getElementById('errorReportBox').innerHTML = endMessage;
86.                 return false;
87.         } else {
88.                 return true;
89.         }
90. }
91.
92. //]]>
93. </script>
94.
95. <form name="screenerForm" action="index.php?loc=survey" onsubmit="return
    checkForm();" method="post">
96.
97. <div class="formSet">
```

```
98.   <div class="formQuestion">First Time:</div>
99.   <div class="formResponse">
100.  <div class="formSet">
101.  <div class="left"><input id="q0" type="checkbox" name="takenBefore" value="yes"
      /></div>
102.  <div class="right"><span class="note">To the best of my knowledge, this is my
      first time taking this survey.</span></div>
103.  </div>
104.  </div>
105.  </div>
106.
107.  <div class="formSet">
108.  <div class="formQuestion">Age Verification:</div>
109.  <div class="formResponse">
110.  <div class="formSet">
111.  <div class="left"><input id="q1" type="checkbox" name="18orolder" value="yes"
      /></div>
112.  <div class="right"><span class="note">I certify that I am 18 years of age or
      older.</span></div>
113.  </div>
114.  </div>
115.  </div>
116.
117.  <div class="formSet">
118.  <div class="formQuestion">Age Range:</div>
119.  <div class="formResponse">
120.  <input type="radio" name="age" value="18to30" /> 18 to 30<br />
121.  <input type="radio" name="age" value="31to45" /> 31 to 45<br />
122.  <input type="radio" name="age" value="46to60" /> 46 to 60<br />
123.  <input type="radio" name="age" value="61over" /> Over 60
124.  </div>
125.  </div>
126.
127.  <div class="formSet">
128.  <div class="formQuestion">Gender:</div>
129.  <div class="formResponse">
130.  <input type="radio" name="gender" value="male" /> Male<br />
131.  <input type="radio" name="gender" value="female" /> Female
132.  </div>
133.  </div>
134.
135.
```

```
136.  <div class="formSet">
137.  <div class="formQuestion">Technical Experience:</div>
138.  <div class="formResponse">
139.  <input type="radio" name="experience" value="1" />Very Experienced<br />
140.  <input type="radio" name="experience" value="2" /> <br />
141.  <input type="radio" name="experience" value="3" /> <br />
142.  <input type="radio" name="experience" value="4" />Some Experience<br />
143.  <input type="radio" name="experience" value="5" /> <br />
144.  <input type="radio" name="experience" value="6" /> <br />
145.  <input type="radio" name="experience" value="7" />No Experience<br />
146.  </div>
147.  </div>
148.
149.  <div class="formSet">
150.  <div class="formQuestion">Country:</div>
151.  <div class="formResponse">
152.                        <select name='country' size='1'>
153.                               <option value='usa'>United States</option>
154.                               ...
155.                        </select>
156.                          
157.                        <p class="note">Select the country where you have spent the
      majority of your life.</p>
158.  </div>
159.  </div>
160.
161.  <div class="formSet">
162.  <div class="formQuestion">Email:</div>
163.  <div class="formResponse">
164.  <input id="emailForm" type="text" name="email" value="" maxlength="60"
      style="width: 200px;" />
165.  <p class="note"><b>You are not required to share your email address.</b> You must
      share your email to be eligible to win the incentive prize. If you win, we will
      contact you through this address.</p>
166.  </div>
167.  </div>
168.
169.  <div class="formSet">
170.  <div class="formQuestion">Consent Form:</div>
171.  <div class="formResponse">
172.  <div class="formSet">
173.  <div class="left"><input id="q7" type="checkbox" name="agreetoterms" value="yes"
      /></div>
```

```
174.  <div class="right"><span class="note">
175.  I agree to the consent form, and acknowledge that this is a scientific study and
      should be treated as such.</span>
176.  <a class="javascriptLink"
      onclick="window.open('docs/consent.html','Consent_Form','scrollbars=auto,height=45
      0,width=550,resizable');">Click here to read the Consent Form.</a></div>
177.  </div>
178.  </div>
179.  </div>
180.
181.  <div class="formSet">
182.  <div class="formQuestion">Are you colorblind?</div>
183.  <div class="formResponse">
184.  <input type="radio" name="colorblind" value="no" /> No, I am not colorblind<br />
185.  <input type="radio" name="colorblind" value="yes" /> Yes, I am in some way
      colorblind<br />
186.  <input type="radio" name="colorblind" value="dontknow" /> I am not sure whether or
      not I am colorblind
187.  </div>
188.  </div>
189.
190.  <div id="errorReportBox"></div>
191.
192.  <div class="formSet">
193.          <div class="formQuestion"> </div>
194.          <div class="formResponse" style="align: center; text-align: center;">
195.                  <input type="hidden" name="loc" value="survey" />
196.                  <input type="image" src="images/start_the_survey.gif"
      onmouseover="this.src='images/start_the_survey_over.gif';"
      onmouseout="this.src='images/start_the_survey.gif';" alt="Start the Survey!" />
197.          </div>
198.  </div>
199.
200.  </form>
201.
202.  <?php
203.  include 'includes/footer.inc';
204.  ?>
205.
206.  </div>
207.
208.  <script type="text/javascript" language="javascript">
209.  //<![CDATA[
```

```
210.
211.  var color = "";
212.  for (var i = 0; i < 50; i++){
213.          if (i < 10){i = "0"+i;}
214.          for (var j = 0; j < 5; j++){
215.                  if (j == 0){color="BLACK";}
216.                  if (j == 1){color="BLUE";}
217.                  if (j == 2){color="ORANGE";}
218.                  if (j == 3){color="RED";}
219.                  if (j == 4){color="GREEN";}
220.                  var newImg = new Image();
221.                  newImg = "icons/"+color+"-"+i+".gif";
222.          }
223.  }
224.  //]]>
225.  </script>
```

Register.inc Annotation

1. Begin PHP code
2. Include ‘header.inc’ to draw a header on the page
3. End PHP code
4. Blank line
5. Set PHP SESSION variable ‘SessionWhere’ to “register”
6. Blank line
7. Add the page title to the top of the page
8. Blank line
9. Begin div which holds primary content
10. Paragraph text
11. Paragraph text
12. Paragraph text
13. Blank line
14. Add two line breaks
15. Blank line
16. Begin JavaScript Code
17. Begin CDATA so all browsers can read JavaScript without error
18. Blank line
19. Begin function ‘checkForm’ which validates user input and generates errors accordingly
20. Create variable ‘q0checked’ and initially set to 1 to validate question 0
21. Create variable ‘q1checked’ and initially set to 1 to validate question 1
22. Create variable ‘q2checked’ and initially set to 1 to validate question 2

```
23.  Create variable 'q3checked' and initially set to 1 to validate question 3
24.  Create variable 'q4checked' and initially set to 1 to validate question 4
25.  Create variable 'q5checked' and initially set to 1 to validate question 5
26.  Create variable 'q6checked' and initially set to 1 to validate question 6
27.  Create variable 'emailchecked' and initially set to 1 to validate user email
28.  Create variable 'endMessage' and initially set to an empty string to contain error
     message script
29.  Blank line
30.  Begin IF statement which runs if question 0 is checked
31.  Set variable 'q0checked' to 0
32.  End IF statement
33.  Begin IF statement which runs if question 1 is checked
34.  Set variable 'q1checked' to 0
35.  End IF statement
36.  Begin FOR loop which checks all radio buttons in group 'age'
37.  Begin IF statement which runs if one of the radio buttons in group 'age' is
     checked
38.  Set variable 'q2checked' to 0
39.  End IF statement
40.  End FOR loop
41.  Begin FOR loop which checks all radio buttons in group 'gender'
42.  Begin IF statement which runs if one of the radio buttons in group 'gender' is
     checked
43.  Set variable 'q3checked' to 0
44.  End IF statement
45.  End FOR loop
46.  Begin FOR loop which checks all radio buttons in group 'experience'
47.  Begin IF statement which runs if one of the radio buttons in group 'experience' is
     checked
48.  Set variable 'q4checked' to 0
49.  End IF statement
50.  End FOR loop
51.  Begin IF statement which runs if question 7 is checked
52.  Set variable 'q7checked' to 0
53.  End IF statement
54.  Begin FOR loop which checks all radio buttons in group 'colorblind'
55.  Begin IF statement which runs if one of the radio buttons in group 'colorblind' is
     checked
56.  Set variable 'q8checked' to 0
57.  End IF statement
58.  End FOR loop
59.  Create array 'characterBlacklist' which contains a character in each cell
     forbidden in email input
```

```
60.   Create variable 'thisString' initially set to the value of input in email form
61.   Create variable 'badcharacters' initially set to an empty string
62.   Blank line
63.   Begin IF statement which tests if email input box contains text
64.   Begin FOR loop which runs through each cell in array 'characterBlacklist'
65.   Begin FOR loop which runs through each character in email input box string
66.   Begin IF statement which tests if email input box contains a character in
      'characterBlacklist'
67.   Set variable 'emailchecked' to 1 to mark that email is invalid
68.   Append character in cell of 'characterBlacklist' to variable 'badcharacters'
69.   End IF statement
70.   End FOR loop
71.   End FOR loop
72.   End IF statement
73.   Blank line
74.   Append divs and text to 'endMessage'
75.   If question 0 is not answered, append error text to 'endMessage'
76.   If question 1 is not answered, append error text to 'endMessage'
77.   If question 2 is not answered, append error text to 'endMessage'
78.   If question 3 is not answered, append error text to 'endMessage'
79.   If question 4 is not answered, append error text to 'endMessage'
80.   If question 7 is not answered, append error text to 'endMessage'
81.   If question 8 is not answered, append error text to 'endMessage'
82.   If the email field contains invalid characters, append error and each invalid
      character to 'endMessage'
83.   Begin IF statement which tests if an error has occurred
84.   Append tags and text to 'endMessage'
85.   Set innerHTML of 'errorReportBox' to 'endMessage' string to display error
86.   Do not exit script
87.   End IF statement, begin ELSE statement
88.   Exit script
89.   End ELSE statement
90.   End function
91.   Blank line
92.   End CDATA
93.   End JavaScript
94.   Blank line
95.   Begin form which runs function 'checkForm' on submit, and if valid, changes page
      to 'survey'
96.   Blank line
97.   Begin div to format input row
98.   Begin div to format text
99.   Begin div to format input
```

```
100.  Begin div to format input row
101.  Create formatted checkbox
102.  Create formatted text
103.  End div
104.  End div
105.  End div
106.  Blank line
107.  Begin div to format input row
108.  Begin div to format text
109.  Begin div to format input
110.  Begin div to format input row
111.  Create formatted checkbox
112.  Create formatted text
113.  End div
114.  End div
115.  End div
116.  Blank line
117.  Begin div to format input row
118.  Begin div to format text
119.  Begin div to format input
120.  Add radio button with text and line break
121.  Add radio button with text and line break
122.  Add radio button with text and line break
123.  Add radio button with text
124.  End div
125.  End div
126.  Blank line
127.  Begin div to format input row
128.  Begin div to format text
129.  Begin div to format input
130.  Add radio button with text and line break
131.  Add radio button with text
132.  End div
133.  End div
134.  Blank line
135.  Blank line
136.  Begin div to format input row
137.  Begin div to format text
138.  Begin div to format input
139.  Add radio button with text and line break
140.  Add radio button with text and line break
141.  Add radio button with text and line break
```

```
142.  Add radio button with text and line break
143.  Add radio button with text and line break
144.  Add radio button with text and line break
145.  Add radio button with text and line break
146.  End div
147.  End div
148.  Empty line
149.  Begin div to format input row
150.  Begin div to format text
151.  Begin div to format input
152.  Begin select box for 'country'
153.  Create option for 'country' select box
154.  List all major nations (cropped for brevity)
155.  End select box
156.  Create two non-breaking spaces
157.  Create paragraph text
158.  End div tag
159.  End div tag
160.  Blank line
161.  Begin div to format input row
162.  Begin div to format text
163.  Begin div to format input
164.  Create formatted checkbox
165.  Create formatted text
166.  End div tag
167.  End div tag
168.  Blank line
169.  Begin div to format input row
170.  Begin div to format text
171.  Begin div to format input
172.  Begin div to format input row
173.  Create formatted checkbox
174.  Create div tag and span tag for formatting
175.  Create formatted text
176.  Add JavaScript link for consent form to display in popup window
177.  End div tag
178.  End div tag
179.  End div tag
180.  Blank line
181.  Begin div to format input row
182.  Begin div to format text
183.  Begin div to format input
```

184. Add radio button with text and line break
185. Add radio button with text and line break
186. Add radio button with text
187. End div tag
188. End div tag
189. Blank line
190. Create div placeholder for error box
191. Blank line
192. Begin div to format start button
193. Begin div to format area
194. Begin div to center button
195. Add hidden 'loc' variable to send user to survey page
196. Add image submit button to send user to survey page
197. End div tag
198. End div tag
199. Blank line
200. End form tag
201. Blank line
202. Begin PHP code
203. Include 'footer.inc' to display the footer information
204. End PHP code
205. Blank line
206. End div tag
207. Blank line
208. Begin JavaScript code
209. Begin CDATA so all browsers can read JavaScript without error
210. Blank line
211. Create variable 'color' initially set to an empty string to change a number to its corresponding color name
212. Begin FOR loop to cycle through all icons
213. If a number is less than 10, append a preceding "0" for formatting purposes
214. Begin FOR loop to cycle through all colors
215. If the icon color equals 0, set 'color' to "BLACK"
216. If the icon color equals 1, set 'color' to "BLUE"
217. If the icon color equals 2, set 'color' to "ORANGE"
218. If the icon color equals 3, set 'color' to "RED"
219. If the icon color equals 4, set 'color' to "GREEN"
220. Create variable 'newImg' which creates a new image object
221. Set 'newImg' to an icon image based on icon number and color so icon preloads before user visits survey page
222. End FOR loop
223. End FOR loop

```
224.  End CDATA
225.  End JavaScript
```

Sendmail.inc Script

```
1.    <?php
2.    include 'includes/header.inc';
3.    ?>
4.
5.    <?php
6.
7.    $emailArray = array();
8.    $wordGroup = $_POST['email'];
9.    $newWord = "";
10.
11.   for ($i = 0; $i < strlen($wordGroup); $i++){
12.           $letter = $wordGroup{$i};
13.           if ($i == strlen($wordGroup)-1){
14.                   $newWord .= $letter;
15.                   array_push($emailArray, $newWord);
16.                   $newWord = "";
17.           } else {
18.                   if ($letter == "," || $letter == ";") {
19.                           array_push($emailArray, $newWord);
20.                           $newWord = "";
21.                   } else if ($letter == " "){
22.                           $newWord = "";
23.                   } else {
24.                           $newWord .= $letter;
25.                   }
26.           }
27.   }
28.
29.   $subject = $_POST['name']." suggests you visit iconstudy.com.";
30.   $body = "Do you want a chance to win $15 to Barnes and Noble? Visit
      www.iconstudy.com!\n\n" .
31.   $_POST['name'] . " has visited www.iconstudy.com and suggests you take a look at
      the site as well.\n\n" . $_POST['message'] . "\n\n
32.   The site www.iconstudy.com is an interactive survey where participants share their
      interpretations of abstract symbols.
33.   This is a scientific study which requires as many participants as possible. If you
      are interested in taking the survey, please visit www.iconstudy.com.
```

```
34.  You could win a a $15 gift certificate to Barnes and Noble
     (www.barnesandnoble.com)! \n\n\n\n ---------------------- \n\n Copyright 2009,
     www.iconstudy.com";
35.
36.  for ($i = 0; $i < count($emailArray); $i++){
37.          $to = $emailArray[$i];
38.          if (mail($to, $subject, $body)) {
39.                  $emailWorked = 1;
40.          }
41.  }
42.  if ($emailWorked == 1){
43.          echo '<div class="header">The Emails have been Sent</div>';
44.          echo "<div class='content' style='align: center; text-align:
     center;'><h2>Message successfully sent!<br />Thank you very much for promoting our
     site.</h2><h2><a href='http://www.iconstudy.com'>Click here to return
     home.</a></h2>";
45.  } else {
46.          include 'includes/badpage.inc';
47.  }
48.
49.  ?>
50.
51.  <?php
52.  include 'includes/footer.inc';
53.  ?>
54.
55.  </div>
```

Sendmail.inc Annotation

```
1.   Begin PHP code
2.   Include ‘header.inc’ to draw a header on the page
3.   End PHP code
4.   Blank line
5.   Begin PHP code
6.   Blank line
7.   Create array ‘emailArray’ to contain the emails in each cell
8.   Create variable ‘wordGroup’ initially set to POSTDATA ‘email’ to contain a
     concatenated list of all submitted email addresses
9.   Create variable ‘newWord’ initially set to an empty string to contain the
     separated email address
10.  Blank line
```

```
11.  Begin FOR loop to run once for every character in 'wordGroup'
12.  Create variable 'letter' and set to the first character in 'wordGroup'
13.  Began IF statement which runs if 'wordGroup' is finished
14.  Append 'letter' to 'newWord'
15.  Add 'newWord' to next cell in 'emailArray' to add an email address
16.  Clear 'newWord'
17.  End IF statement, begin ELSE statement
18.  Begin IF statement which runs if the character is a separating character ("'" or
     ";")
19.  Add 'newWord' to next cell in 'emailArray' to add an email address
20.  Clear 'newWord'
21.  End IF statement, begin ELSE IF statement which runs if 'letter' equals " " to
     ignore the space
22.  Clear 'newWord'
23.  End ELSE IF statement, begin ELSE statement
24.  Append 'letter' to 'newWord' to build an email address
25.  End ELSE statement
26.  End IF statement
27.  End FOR loop
28.  Blank line
29.  Create variable 'subject' and initially set it to POSTDATA 'name' and text
30.  Create variable 'body' and initially set it to text
31.  Text line to be present in email with POSTDATA
32.  Text line to be present in email
33.  Text line to be present in email
34.  Text line to be present in email
35.  Blank line
36.  Begin FOR loop and run for every email cell in 'emailArray'
37.  Create variable 'to' and initially set to the selected cell in 'emailArray'
38.  Begin IF statement which sends mail using preset parameters
39.  Create variable 'emailWorked' and initially set to 1, confirming the email has
     been sent
40.  End IF statement
41.  End FOR loop
42.  Begin IF statement which tests if 'emailWorked' equals 1, indicating that email
     has been sent
43.  Write formatted text to page
44.  Write formatted text to page with hyperlink back to home page
45.  End IF statement, and begin ELSE statement
46.  Include 'badpage.inc' to add the page script that shows if a user is not permitted
     to view the page
47.  End ELSE statement
48.  Blank line
```

```
49.    End PHP code
50.    Blank line
51.    Begin PHP code
52.    Include 'footer.inc' to draw the bottom part of the page
53.    End PHP code
54.    Blank line
55.    End div tag
```

Submit.inc Script

```
1.     <?php
2.     include 'includes/header.inc';
3.     ?>
4.
5.     <?php
6.
7.     if ($_SESSION['SessionWhere'] == "survey"){
8.            $_SESSION['SessionWhere'] = "submit";
9.
10.    do {
11.           $uniqueID = rand(0, 1000000);
12.           $redo = 0;
13.           mysql_connect($v_DBHostName,$v_DBUserName,$v_DBPassword);
14.           $v_dbLinkUserList =
       mysql_connect($v_DBHostName,$v_DBUserName,$v_DBPassword);
15.           mysql_select_db("bdparker_bdparkerDB");
16.           $v_TheQueryUserList = "SELECT * FROM `iconstudy_users` WHERE
       uniqueID='".$uniqueID."'";
17.           $v_TheResultUserList = mysql_query($v_TheQueryUserList);
18.           $v_NumberOfRowsUserList = mysql_num_rows($v_TheResultUserList);
19.           mysql_close($v_dbLinkUserList);
20.           if ($v_TheResultUserList) {
21.                   while ($v_rowUserList = mysql_fetch_array ($v_TheResultUserList,
       MYSQL_ASSOC)) {
22.                           $v_recordsUserList[] = $v_rowUserList;
23.                   }
24.           }
25.           if ($v_recordsUserList){
26.           foreach ($v_recordsUserList as $v_CurrentRecordUserList) {
27.                   foreach ($v_CurrentRecordUserList as $v_indexUserList =>
       $v_CurrentFieldUserList) {
28.                   }
```

```
29.                 if ($v_CurrentRecordUserList['uniqueID'] != ""){
30.                         $redo = 1;
31.                         }
32.                 }
33.         }
34.  } while ($redo == 1);
35.
36.  $thisEmail = $_POST['email'];
37.  if ($thisEmail == ""){
38.         $thisEmail = "noemail";
39.  }
40.
41.  mysql_connect($v_DBHostName,$v_DBUserName,$v_DBPassword);
42.  $v_dbLink = mysql_connect($v_DBHostName,$v_DBUserName,$v_DBPassword);
43.  mysql_select_db("bdparker_bdparkerDB");
44.  $v_TheQuery = "INSERT INTO `iconstudy_users`
     (`user_id`,`uniqueID`,`date`,`agerange`,`gender`,`technicalexpertise`,`country`,`e
     mail`,`colorblind`) VALUES ('', '".$uniqueID."', '".date('F j, Y, g:i a')."',
     '".$_POST['age']."', '".$_POST['gender']."', '".$_POST['experience']."',
     '".$_POST['country']."', '".$thisEmail."', '".$_POST['colorblind']."')";
45.  $v_TheResult = mysql_query($v_TheQuery);
46.  $v_NumberOfRowsInserted = mysql_affected_rows($v_dbLink);
47.  mysql_close($v_dbLink);
48.
49.  for ($i = 0; $i < 50; $i++){
50.         $responseArray = array();
51.         $wordGroup = $_POST['b'.$i];//"AA|BB|CC|SS|";
52.         $newWord = "";
53.         for ($j = 0; $j < strlen($wordGroup); $j++){
54.                 $letter = $wordGroup{$j};
55.                 if ($letter == "|") {
56.                         if ($newWord != ""){
57.                                 array_push($responseArray, $newWord);
58.                                 $newWord = "";
59.                         }
60.                 } else {
61.                         $newWord .= $letter;
62.                 }
63.         }
64.         for ($k = 0; $k < count($responseArray); $k++){
65.                 mysql_connect($v_DBHostName,$v_DBUserName,$v_DBPassword);
66.                 $v_dbLink2 =
     mysql_connect($v_DBHostName,$v_DBUserName,$v_DBPassword);
```

```
67.                 mysql_select_db("bdparker_bdparkerDB");
68.                 $v_TheQuery2 = "INSERT INTO `iconstudy_responses`
      (`response_id`,`uniqueID`,`date`,`iconnumber`,`iconcolor`,`iconresponse`) VALUES
      ('', '".$uniqueID."', '".date('F j, Y, g:i a')."', '".$_POST['a'.$i]."',
      '".$_POST['c'.$i]."', '".$responseArray[$k]."')";

69.                 $v_TheResult2 = mysql_query($v_TheQuery2);
70.                 $v_NumberOfRowsInserted2 = mysql_affected_rows($v_dbLink2);
71.                 mysql_close($v_dbLink2);
72.         }
73.   }
74.
75.   ?>
76.
77.   <div class="header">Submitting Your Responses</div>
78.
79.   <div class="content" style="align: center; text-align: center;">
80.   Thank you for your participation!<br /><br />
81.   Your answers have been submitted to our database.<br /><br />
82.   <br /><br />
83.   <a href="http://www.iconstudy.com">Click here to return to the home page.</a>
84.
85.   <?php
86.   include 'includes/footer.inc';
87.   ?>
88.
89.   <?php
90.
91.   } else {
92.
93.   include 'includes/header.inc';
94.   include 'includes/badpage.inc';
95.
96.   }
97.
98.   ?>
99.
100.  </div>
```

Submit.inc Annotation

```
1.    Begin PHP code
```

2. Include 'header.inc' to draw a header on the page
3. End PHP code
4. Blank line
5. Begin PHP code
6. Blank line
7. Begin IF statement which runs if the user arrived at this page from the survey page
8. Set SESSION 'SessionWhere' to "submit"
9. Blank line
10. Begin DO WHILE loop to assign a unique random integer between 0 and 1,000,000
11. Create variable 'uniqueID' initially set it to a random number between 0 and 1,000,000
12. Create variable 'redo' initially set to 0 which manages the completion of the DO WHILE loop
13. Connect to MySQL database using predetermined parameters
14. Create variable 'v_dbLinkUserList' initially set to connect to the MySQL database
15. Select MySQL Database "**********"(database name has been removed for security purposes)
16. Create variable 'v_TheQueryUserList' initially set to a MySQL query to collect the 'uniqueID' of all users
17. Create variable 'v_TheResultUserList' initially set to the executed MySQL query 'v_TheQueryUserList'
18. Create variable 'v_NumberOfRowsUserList' initially set to the number of rows in 'v_TheResultUserList'
19. Close MySQL connection 'v_dbLinkUserList'
20. Begin IF statement which runs if the query yielded results
21. Begin WHILE loop which runs if there is a row
22. Create array 'v_recordsUserList' initially set to row data in 'v_rowUserList'
23. End WHILE loop
24. End IF statement
25. Begin IF statement which runs if the query yielded results
26. Begin FOREACH loop which turns each data into a record
27. Begin FOREACH loop which turns each data into an associative array
28. End FOREACH loop
29. Begin IF statement which runs if the current record is not an empty string, indicating that 'uniqueID' is a duplicate
30. Set variable 'redo' to equal 1
31. End IF statement
32. End FOREACH loop
33. End IF statement
34. End DO WHILE if 'redo' is equal to 1, otherwise repeat
35. Blank line
36. Create variable 'thisEmail' initially set to POSTDATA 'email'

```
37.  Begin IF statement which runs if 'thisEmail' is an empty string
38.  If the user left no email, set 'thisEmail' to "noemail"
39.  End IF statement
40.  Blank line
41.  Connect to MySQL database using predetermined parameters
42.  Create variable 'v_dbLink' initially set to connect to the MySQL database
43.  Select MySQL Database "******************"(database name has been removed for
     security purposes)
44.  Create variable 'v_TheQuery' initially set to a MySQL query to insert all data
     into a database table
45.  Create variable 'v_TheResult' initially set to the executed MySQL query
     'v_TheQuery'
46.  Create variable 'v_NumberOfRowsInserted' initially set the number of rows affected
47.  Close MySQL connection 'v_dbLink'
48.  Blank line
49.  Begin FOR loop which cycles through 50 times to collect data from the POSTDATA
     arrays
50.  Create array 'responseArray' to collect the POSTDATA responses
51.  Create variable 'wordGroup initially set to the response POSTDATA
52.  Create variable 'newWord' initially set to an empty string
53.  Begin FOR loop which runs through every character in 'wordGroup'
54.  Create variable 'letter' initially set to an assigned cell in 'wordGroup'
55.  Begin IF statement which runs if 'letter' contains a separator ("|")
56.  Begin IF statement which runs if 'newWord' is not an empty string
57.  Add 'newWord' to 'responseArray'
58.  Set 'newWord' to an empty string, clearing it
59.  End IF statement
60.  End IF statement, begin ELSE statement
61.  Append 'letter' to 'newWord'
62.  End ELSE statement
63.  End FOR loop
64.  Begin FOR loop which runs once for every response provided for the given icon
65.  Connect to MySQL database using predetermined parameters
66.  Create variable 'v_dbLink2' initially set to connect to the MySQL database
67.  Select MySQL Database "******************"(database name has been removed for
     security purposes)
68.  Create variable 'v_TheQuery2' initially set to a MySQL query to insert all data
     into a database table
69.  Create variable 'v_TheResult2' initially set to the executed MySQL query
     'v_TheQuery2'
70.  Create variable 'v_NumberOfRowsInserted2' initially set the number of rows
     affected
71.  Close MySQL connection 'v_dbLink2'
```

```
End FOR loop
End FOR loop
Blank line
End PHP code
Blank line
Add formatted text
Blank line
Begin div to center text
Add text and two line breaks
Add text and two line breaks
Add two line breaks
Add link to home page
Blank line
Begin PHP code
Include 'footer.inc' to draw the bottom part of the page
End PHP code
Blank line
Begin PHP code
Blank line
End IF statement, begin ELSE statement
Blank line
Include 'header.inc' to draw the header of the page
Include 'badpage.inc' to add the page script that shows if a user is not permitted to view the page
Blank line
End ELSE statement
Blank line
End PHP code
Blank line
End div tag
```

Survey.inc Script

```
<?php

if ($_POST['18orolder'] != "" && $_POST['age'] != "" && $_POST['country'] != "" && $_POST['experience'] != "" && $_POST['gender'] != "" && $_POST['agreetoterms'] != "" && $_POST['colorblind'] != "" && $_SESSION['SessionWhere'] == "register"){

$_SESSION['SessionWhere'] = "survey";

?>
```

```
8.
9.      <div id="counter" class="progressBarSolid" style="width: 1px;"></div>
10.     <div id="counterFrame" class="progressBarBorder">Progress: <span
        id="counterText">1</span> of 50</div>
11.     <div id="errorBox" class="errorPlaceholder"></div>
12.
13.     <?php include 'includes/header.inc'; ?>
14.
15.     <div class="header">Survey</div>
16.
17.     <div class="content">
18.
19.     <div id="mainPanel">
20.
21.     <script type="text/javascript" language="javascript">
22.     //<![CDATA[
23.
24.     var myResponses = new Array();
25.     var whichIconsAreFinished = new Array();
26.     var iconArrayOrder = new Array();
27.     var iconArrayColors = new Array();
28.     var iconArrayResponses = new Array();
29.     var choicesArray = new Array();
30.     for (var i = 0; i < 50; i++){
31.     choicesArray[i] = i;
32.     }
33.
34.     var numIcons = 50;
35.     var numColors = 5;
36.     var whichIcon;
37.     var whichColor;
38.     var colorName;
39.     var counter = 0;
40.     var doublePress = 0;
41.     var isTimeOutGoing = 0;
42.     var isErrorOn = 0;
43.
44.     function submitResponse(){
45.     var foundDuplicate = 0;
46.     var thisString = document.getElementById('responseBox').value;
```

```
47.   var characterBlacklist = new
      Array("<",">","/","\\","{","}","[","]","`","~","?",",",":",";","|","+","=","_","!"
      ,"@","#","$","%","^","&","*","(",")");
48.   for (var i = 0; i < characterBlacklist.length; i++){
49.     for (var j = 0; j < thisString.length; j++)
50.       thisString = thisString.replace(characterBlacklist[i], "");
51.     }
52.   }
53.   for (var i = 0; i < myResponses.length; i++){
54.     if (thisString == myResponses[i]){
55.       foundDuplicate = 1;
56.     }
57.   }
58.   if (foundDuplicate == 1){
59.     generateError("You have already added that response. You cannot submit the same
      term more than once.");
60.   }
61.   if (thisString != "" && foundDuplicate == 0){
62.     myResponses.push(thisString);
63.     writeResponse();
64.     doublePress = 0;
65.   }
66.   refocus();
67.   }
68.
69.   function eraseResponse(which){
70.   myResponses.splice(which,1);
71.   writeResponse();
72.   }
73.
74.   function writeResponse(){
75.   document.getElementById('responseBox').value = "";
76.   document.getElementById('responseArray').innerHTML='';
77.   for (var i = 0; i < myResponses.length; i++){
78.     document.getElementById('responseArray').innerHTML += "<span class='erase'
      onclick='eraseResponse("+i+");'>[Erase]</span>" + myResponses[i] + "<br />";
79.   }
80.   refocus();
81.   }
82.
83.   function finish(){
84.   if (document.getElementById('responseBox').value != ""){
85.     submitResponse();
```

```
86.     return;
87.   }
88.   if (myResponses.length == 0 && counter > 0){
89.     return;
90.   }
91.   var allResponses = "";
92.   for (var i = 0; i < myResponses.length; i++){
93.     allResponses += myResponses[i]+"|";
94.   }
95.   if (whichIcon == "00"){whichIcon = 0;}
96.   if (whichIcon == "01"){whichIcon = 1;}
97.   if (whichIcon == "02"){whichIcon = 2;}
98.   if (whichIcon == "03"){whichIcon = 3;}
99.   if (whichIcon == "04"){whichIcon = 4;}
100.  if (whichIcon == "05"){whichIcon = 5;}
101.  if (whichIcon == "06"){whichIcon = 6;}
102.  if (whichIcon == "07"){whichIcon = 7;}
103.  if (whichIcon == "08"){whichIcon = 8;}
104.  if (whichIcon == "09"){whichIcon = 9;}
105.  iconArrayResponses[whichIcon] = allResponses;
106.  iconArrayColors[whichIcon] = whichColor;
107.  iconArrayOrder[whichIcon] = whichIcon;
108.  document.getElementById('responseArray').innerHTML = "";
109.  myResponses = [];
110.  chooseIcon ();
111.  counter ++;
112.  var counterMod = 0;
113.  if (counter > 0) {
114.    counterMod = counter-1;
115.  }
116.  document.getElementById('counter').style.width = (counterMod*10) + 'px';
117.  document.getElementById('counterText').innerHTML = counterMod;
118.  refocus();
119.  testForEnd();
120.  }
121.
122.  function refocus(){
123.  document.getElementById('responseBox').focus();
124.  }
125.
126.  function testForEnd(){
127.  if (counter > 50){
```

```
128.    var endingFormCode = "";
129.    endingFormCode = "<form name='sendingForm' action='index.php?loc=submit'
      method='POST'>";
130.    <?php print("endingFormCode += '<input type=\'hidden\' name=\'takenBefore\'
      value=\'".$_POST['takenBefore']."\' />';");?>
131.    <?php print("endingFormCode += '<input type=\'hidden\' name=\'18orolder\'
      value=\'".$_POST['18orolder']."\' />';");?>
132.    <?php print("endingFormCode += '<input type=\'hidden\' name=\'age\'
      value=\'".$_POST['age']."\' />';");?>
133.    <?php print("endingFormCode += '<input type=\'hidden\' name=\'country\'
      value=\'".$_POST['country']."\' />';");?>
134.    <?php print("endingFormCode += '<input type=\'hidden\' name=\'experience\'
      value=\'".$_POST['experience']."\' />';");?>
135.    <?php print("endingFormCode += '<input type=\'hidden\' name=\'gender\'
      value=\'".$_POST['gender']."\' />';");?>
136.    <?php print("endingFormCode += '<input type=\'hidden\' name=\'email\'
      value=\'".$_POST['email']."\' />';");?>
137.    <?php print("endingFormCode += '<input type=\'hidden\' name=\'agreetoterms\'
      value=\'".$_POST['agreetoterms']."\' />';");?>
138.    <?php print("endingFormCode += '<input type=\'hidden\' name=\'colorblind\'
      value=\'".$_POST['colorblind']."\' />';");?>
139.    for (var x = 0; x < iconArrayResponses.length; x++){
140.      endingFormCode += "<input type='hidden' name='b"+x+"'
      value='"+iconArrayResponses[x]+"' />";
141.    }
142.    for (var x = 0; x < iconArrayColors.length; x++){
143.      endingFormCode += "<input type='hidden' name='c"+x+"'
      value='"+iconArrayColors[x]+"' />";
144.    }
145.    for (var x = 0; x < iconArrayOrder.length; x++){
146.      endingFormCode += "<input type='hidden' name='a"+x+"'
      value='"+iconArrayOrder[x]+"' />";
147.    }
148.    endingFormCode += "<div style='text-align: center;'>";
149.    endingFormCode += "<h2>You are done!</h2><h3>The survey is complete. Click the
      submit button below to send your responses to us.</h3>";
150.    endingFormCode += "<input type='image' src='images/submit.gif'
      onmouseover='this.src=\"images/submit_over.gif\";'
      onmouseout='this.src=\"images/submit.gif\";' alt='Submit' style='margin-top: 50px;
      margin-bottom: 100px;' />";
151.    endingFormCode += "</div>";
152.    document.getElementById('mainPanel').innerHTML = endingFormCode;
153.  }
154.  }
```

```
155.
156.  function setCharAt(str,index,chr) {
157.  if(index > str.length-1) return str;
158.  return str.substr(0,index) + chr + str.substr(index+1);
159.  }
160.
161.  function checkKey(e){ //e is event object passed from function invocation
162.  var characterCode;
163.  if(e && e.which){ //if which property of event object is supported (NN4)
164.    e = e
165.    characterCode = e.which //character code is contained in NN4's which property
166.  } else {
167.    e = event
168.    characterCode = e.keyCode //character code is contained in IE's keyCode property
169.  }
170.  if(characterCode == 13){ //if generated character code is equal to ascii 13 (if
      enter key)
171.    manageDoublePress();
172.    if (isErrorOn == 1){
173.      removeError();
174.    } else {
175.      submitResponse();
176.    }
177.  } else {
178.    removeError();
179.  }
180.  }
181.
182.  function manageDoublePress(){
183.  doublePress ++;
184.  if (isTimeOutGoing == 0){
185.    setTimeout("doublePress = 0; isTimeOutGoing = 0;",1000);
186.    isTimeOutGoing = 1;
187.  }
188.  if (doublePress >= 2){
189.    finish();
190.    doublePress = 0;
191.  }
192.  }
193.
194.  function chooseIcon (){
195.  var arrayLocation = Math.floor(Math.random()*choicesArray.length);
```

```
196.  whichIcon = choicesArray[arrayLocation];
197.  whichColor = Math.ceil(Math.random()*numColors);
198.  colorName = "BLACK";
199.  if (whichColor == 1) {colorName = "BLACK";}
200.  if (whichColor == 2) {colorName = "RED";}
201.  if (whichColor == 3) {colorName = "BLUE";}
202.  if (whichColor == 4) {colorName = "GREEN";}
203.  if (whichColor == 5) {colorName = "ORANGE";}
204.  choicesArray.splice(arrayLocation,1);
205.  if (whichIcon < 10) {
206.    whichIcon = "0"+whichIcon;
207.  }
208.  document.getElementById('imgIcon').src="icons/"+colorName+"-"+whichIcon+".gif";
209.  document.getElementById('imgIcon').alt="Icon #"+whichIcon;
210.  }
211.
212.  function generateError(message){
213.  document.getElementById('errorBox').innerHTML = "<div class='errorMessage'>" +
      message + "<br /><span onclick='removeError();'>[close]</span></div>";
214.  isErrorOn = 1;
215.  }
216.
217.  function removeError(){
218.  document.getElementById('errorBox').innerHTML = "";
219.  isErrorOn = 0;
220.  doublePress = 0;
221.  }
222.
223.  document.write('<div class="surveyFormBox">');
224.  document.write('<div class="surveyFormIcon">');
225.  document.write("<img id='imgIcon' src='' alt='' class='icon' />");
226.  document.write('<p>Enter a word or phrase in the box to the right that the images
      represents. Press "+" or the Enter key on your keyboard to add your response. You
      may write as many or as few answers as you wish. Press "Finish" or the Enter key
      twice quickly to see the next image.</p>');
227.  document.write('</div>');
228.  document.write('<div class="surveyFormContainer">');
229.  document.write('<table border="0"><tr><td>');
230.  document.write('<input autocomplete="off" type="text" id="responseBox"
      class="surveyMainInput" name="mainInputText" onKeyPress="checkKey(event);" />');
231.  document.write('</td><td>');
232.  document.write('<input type="button" value="+" class="surveyAddButton"
      onclick="submitResponse();" />');
```

```
233.  document.write('</td></tr>');
234.  document.write('<tr><td colspan="2"><div class="surveyResponseBox"
      id="responseArray"></div></td></tr>');
235.  document.write('<tr><td colspan="2"><form action="finish();" name="endInput">');
236.  document.write('<input type="button" value="Finish" class="surveyFinishButton"
      onclick="finish();" />');
237.  document.write('</form></td></tr></table>');
238.  document.write('</div>');
239.  document.write('</div>');
240.
241.  finish ();
242.  setInterval("refocus();",500);
243.
244.  //]]>
245.  </script>
246.
247.  </div>
248.
249.  <?php
250.  include 'includes/footer.inc';
251.  ?>
252.
253.  </div>
254.
255.  <br />
256.
257.  <?php
258.
259.  } else {
260.
261.  include 'includes/header.inc';
262.  include 'includes/badpage.inc';
263.
264.  }
265.  ?>
```

Survey.inc Annotation

1. Begin PHP code
2. Blank line
3. Begin IF statement if the SESSION variable states that the user came from the registration page and all necessary POSTDATA exists

4. Blank line
5. Set SESSION 'SessionWhere' to 'survey'
6. Blank line
7. End PHP code
8. Blank line
9. Add the Progress Bar to the top of the page
10. Add the Progress text to show the user how many icons remain
11. Add error box which is initially invisible
12. Blank line
13. Begin PHP code, include the header.inc file, end PHP code
14. Blank line
15. Add the page title to the top of the page
16. Blank line
17. Begin div which guides most of the site's layout
18. Blank line
19. Begin div which holds primary content
20. Blank line
21. Begin JavaScript
22. Begin CDATA so all browsers can read JavaScript without error
23. Blank line
24. Create array 'myResponses' to temporarily hold the user's list of interpretations
25. Create array 'whichIconsAreFinished' to list which icon numbers have been answered
26. Create array 'iconArrayOrder' to list which order the icons were presented by icon number
27. Create array 'iconArrayColors' to list which color the icon was with respect to its position in 'iconArrayOrder'
28. Create array 'iconArrayResponses' to permanently hold the responses for each icon with respect to their positions in 'iconArrayOrder'
29. Create array 'choicesArray' to initially contain all possible icon numbers
30. Begin FOR loop which fills choicesArray with 50 cells with an ordered number
31. Set choicesArray to a number with respect to its position in the array. These numbers represent the number of each icon.
32. End FOR loop
33. Blank line
34. Create variable 'numIcons' and initially set to 50 to indicate the number of icons used in the experiment
35. Create variable 'numColors' and initially set to 5 to indicate the number of colors used in the experiment
36. Create variable 'whichIcon' to show which icon is currently selected
37. Create variable 'whichColor' to show which color is currently selected
38. Create variable 'colorName' to match a color number (from 'whichColor') to a string name

```
39.  Create variable 'counter' and initially set to 0 to indicate how many icons have
     been interpreted
40.  Create variable 'whichIcon' and initially set to 0 to manage the status of the
     double-press for the enter key
41.  Create variable 'isTimeOutGoing' and initially set to 0 to manage the status of
     the double-press timeout
42.  Create variable 'isErrorOn' and initially set to 0 to manage the status of whether
     an error is present
43.  Blank line
44.  Begin function 'submitResponse'
45.  Create variable 'foundDuplicate' and initially set to 0 to indicate whether the
     user has already submitted a particular response
46.  Create variable 'thisString' and initially set to the string value of the input
     box
47.  Create array 'characterBlacklist' which contains all invalid characters for the
     responses
48.  Begin FOR loop to repeat for all characters in array 'characterBlacklist'
49.  Begin FOR loop to repear for all characters in string in the input box
50.  Erase the character in 'thisString' if it is found in the array
     'characterBlacklist'
51.  End FOR loop
52.  End FOR loop
53.  Begin FOR loop to repeat for all fields in array 'myResponses'
54.  Begin IF statement which tests if the current input is already in array
     'myResposnes'
55.  Set 'foundDuplicate' to 1
56.  End IF statement
57.  End FOR loop
58.  Begin IF statement which runs if the user's submission is already on the response
     list
59.  Call the function 'generateError' to display "You have already added that
     response. You cannot submit the same term more than once." In the error box
60.  End IF statement
61.  Begin IF statement which runs if the user does not have an empty response box and
     no duplicate was found in the response list
62.  Add the current user response to the response list
63.  Call the function 'writeResponse' to refresh the list
64.  Set 'doublePress' to 0, resetting the double press mechanism
65.  End IF statement
66.  Call function 'refocus' to set the focus back to the input box
67.  End FOR loop
68.  Blank line
69.  Begin function 'eraseResponse' with parameter 'which' to clear the respective
     input from the reponse box
```

```
70.  Remove response from position designated by 'which' from 'myResponses'
71.  Call function 'writeResponses' to refresh list of responses in response box
72.  End function
73.  Blank line
74.  Begin function 'writeResponse' to refresh the responses list in the response box
75.  Clear response input box
76.  Clear innerHTML of response list
77.  Begin FOR loop which displays the responses in the array 'myResponses'
78.  Display an "[Erase]" button and a response from the array 'myResponses'  in the
     innerHTML of response list
79.  End FOR loop
80.  Call function 'refocus' to set the focus back to the input box
81.  End function
82.  Blank line
83.  Begin function 'finish' to save response list, present a new icon, and test for
     the end of the survey
84.  Begin IF statement that tests if the user has an answer in the response box, and
     if so, submit the response and end the function
85.  Run function 'submitResponse' to add response to the response list
86.  Stop the function
87.  End IF statement
88.  Begin IF statement to test if the user has not submitted a response the user has
     not started the survey
89.  Stop the function
90.  End IF statement
91.  Create variable 'allResponses' and initially set to an empty string to contain all
     responses in array 'myResponses' separated by "|"
92.  Begin FOR loop to add all data from array 'myResponses' to variable 'allResponses'
93.  Add array 'myReponses' to 'allResponses' and end with "|"
94.  End FOR loop
95.  Begin and end IF statement to set whichIcon to 0 if whichIcon = '00' so data is
     entered properly
96.  Begin and end IF statement to set whichIcon to 1 if whichIcon = '01' so data is
     entered properly
97.  Begin and end IF statement to set whichIcon to 2 if whichIcon = '02' so data is
     entered properly
98.  Begin and end IF statement to set whichIcon to 3 if whichIcon = '03' so data is
     entered properly
99.  Begin and end IF statement to set whichIcon to 4 if whichIcon = '04' so data is
     entered properly
100. Begin and end IF statement to set whichIcon to 5 if whichIcon = '05' so data is
     entered properly
101. Begin and end IF statement to set whichIcon to 6 if whichIcon = '06' so data is
     entered properly
```

```
102.  Begin and end IF statement to set whichIcon to 7 if whichIcon = '07' so data is
      entered properly
103.  Begin and end IF statement to set whichIcon to 8 if whichIcon = '08' so data is
      entered properly
104.  Begin and end IF statement to set whichIcon to 9 if whichIcon = '09' so data is
      entered properly
105.  Set the cell in 'iconArrayResponses' whose location equals 'whichIcon' to hold all
      user responses for the currently assigned icon
106.  Set the cell in 'iconArrayColor' whose location equals 'whichIcon' to hold the
      color for the currently assigned icon
107.  Set the cell in 'iconArrayOrder' whose location equals 'whichIcon' to hold the
      icon number for the currently assigned icon
108.  Clear innerHTML in 'responseArray' to empty the response box
109.  Clear array 'myResponses'
110.  Run function 'chooseIcon' to randomly assign a new icon
111.  Add 1 to counter
112.  Create variable 'counterMod' and initially set to 0 to contain a modified version
      of the 'counter' variable for formatting purposes
113.  Begin IF statement which tests if counter is greater than 0, showing if survey has
      started
114.  Set 'counterMod' to 1 less than 'counter'
115.  End IF statement
116.  Change width of the div of id 'counter' to 10 times 'counterMod'
117.  Change counter text to read 'counterMod'
118.  Call function 'refocus' to set the focus back to the input box
119.  Call function 'testForEnd' to check if survey is complete
120.  End function
121.  Blank Line
122.  Begin function 'refocus' to put focus on input box
123.  Force focus on input box
124.  End function
125.  Blank Line
126.  Begin function 'testForEnd' to check if the survey is finished
127.  Begin IF statement to test if 'counter' is greater than 50, and if so, produce
      completion page
128.  Create variable 'endingFormCode' and initially set it to an empty string which
      will later contain the HTML to display the ending survey script
129.  Set 'endingFormCode' to contain start form that sends all current POSTDATA as
      POSTDATA and new survey information to the "submit" page when submitted
130.  Begin PHP code, add hidden POSTDATA 'takenBefore' to 'endingFormCode', end PHP
      code
131.  Begin PHP code, add hidden POSTDATA '18orolder' to 'endingFormCode', end PHP code
132.  Begin PHP code, add hidden POSTDATA 'age' to 'endingFormCode', end PHP code
133.  Begin PHP code, add hidden POSTDATA 'country' to 'endingFormCode', end PHP code
```

```
134.  Begin PHP code, add hidden POSTDATA 'experience' to 'endingFormCode', end PHP code
135.  Begin PHP code, add hidden POSTDATA 'gender' to 'endingFormCode', end PHP code
136.  Begin PHP code, add hidden POSTDATA 'email' to 'endingFormCode', end PHP code
137.  Begin PHP code, add hidden POSTDATA 'agreetoterms' to 'endingFormCode', end PHP
      code
138.  Begin PHP code, add hidden POSTDATA 'colorblind' to 'endingFormCode', end PHP code
139.  Begin FOR loop which runs for the length of all responses
140.  Append hidden 'iconArrayResponses' data to 'endingFormCode' to be sent as POSTDATA
141.  End FOR loop
142.  Begin FOR loop which runs for the length of all responses
143.  Append hidden 'iconArrayColors' data to 'endingFormCode' to be sent as POSTDATA
144.  End FOR loop
145.  Begin FOR loop which runs for the length of all responses
146.  Append hidden 'iconArrayOrder' data to 'endingFormCode' to be sent as POSTDATA
147.  End FOR loop
148.  Append div to 'endingFormCode'
149.  Append heading to 'endingFormCode'
150.  Append submit button to 'endingFormCode'
151.  Append end div to 'endingFormCode'
152.  Set innerHTML of 'mainpanel' to 'endingFormCode' to display ending script and
      submit button
153.  End IF statement
154.  End function
155.  Begin function 'setCharAt' with parameters 'str', 'index', and 'chr' to SEOMTHING
156.  Begin IF statement to test if(index > str.length-1) return str;
157.  return str.substr(0,index) + chr + str.substr(index+1);
158.  }
159.  Begin function 'checkKey' with parameter 'e' which listens for key presses
160.  Set variable 'characterCode' to be set to a particular ascii code corresponding to
      a key
161.  Begin IF statement to test which property of an event is supported by certain
      browsers
162.  Set e to e, an event test
163.  Set 'characterCode' to 'e.which', a character code used in NN4
164.  End IF statement, begin ELSE statement
165.  Set e to event, an event test
166.  Set 'characterCode' to e.keyCode, a character code used in IE
167.  End ELSE statement
168.  Begin IF statement to test if 'characterCode' equals 13, which indicates the
      "Enter" key has been pressed
169.  Run function 'manageDoublePress' to run double-press properties
170.  Begin IF statement to test if 'isErrorOn' equals 1 so the error can be removed
171.  Run function 'removeError' to make error message invisible when enter is pressed
```

```
End IF statement, begin ELSE statement
Run function 'submitResponse' to add response when enter is pressed
End ELSE statement
End IF statement, begin ELSE statement
Run function 'removeError' to make error message invisible when enter is pressed
End ELSE statement
End function
Blank line
Begin function 'manageDoublePress' which listens for and acts on double-pressing enter
Add 1 to 'doublePress'
Begin IF statement to test 'isTimeOutGoing' equals 0 so timeout can initiate
Set 'doublePress' to 0 and 'isTimeOutGoing to 0 in 1000 milliseconds to reset double-press if not completed
Set 'isTimeOutGoing' to 1 to show that double-press has initiated
End IF statement
Begin IF statement to test if 'doublePress' is greater than or equal to 2 so double-press can complete
Run function 'finish' to submit the new input or advance in the survey
Set 'doublePress' to 0, resetting the double-press mechanism
End IF statement
End function
Blank line
Start function 'chooseIcon' which randomly assigns a new icon and color to the survey
Create variable 'arrayLocation' and initially set it to a random whole number between 0 and the number of icons that remain
Set variable 'whichIcon' to the corresponding cell in 'choicesArray'
Set variable 'whichColor' to a random whole number between 0 and the number of possible colors
Set 'colorName' to "BLACK" as default
Begin IF statement which tests if 'whichColor' equals 1, and if so, set 'colorName' to "BLACK" and end IF statement
Begin IF statement which tests if 'whichColor' equals 2, and if so, set 'colorName' to "RED" and end IF statement
Begin IF statement which tests if 'whichColor' equals 3, and if so, set 'colorName' to "BLUE" and end IF statement
Begin IF statement which tests if 'whichColor' equals 4, and if so, set 'colorName' to "GREEN" and end IF statement
Begin IF statement which tests if 'whichColor' equals 5, and if so, set 'colorName' to "ORANGE" and end IF statement
Remove chosen icon from 'choiceArray' so it is not selected again
Begin IF statement which tests if 'whichIcon' is less than 10 so numbers can have a preceding "0"
```

```
204.  Set 'whichIcon' to have a preceding "0"
205.  End IF statement
206.  Change icon image to the correct icon and color
207.  Change icon alternate text to display the icon number
208.  End function
209.  Blank line
210.  Start function 'generateError' with parameter 'message' to display an error
      message
211.  Set innerHTML of 'errorBox' to display the error message as 'message' and show a
      close button on a new line
212.  Set 'isErrorOn' to 1 which turns on the error on
213.  End function
214.  Blank line
215.  Start function 'removeError' to erase error message if present
216.  Clear innerHTML of 'errorBox' to remove error message
217.  Set variable 'isErrorOn' to 0 which turns the error off
218.  Set variable 'doublePress' to 0 which resets the double-pressing feature
219.  End function
220.  Blank line
221.  Write div which positions survey elements
222.  Write div which contains survey formatting
223.  Write image which displays icon
224.  Write paragraph tag containing instructions
225.  Write end div
226.  Write start div for containing the survey input
227.  Write start table, start table row, start table data
228.  Write input box for responses
229.  Write end table data, start table data
230.  Write add button
231.  Write end table data, end table row
232.  Write start table row, start table cell, start div which displays the response
      box, end div, end table data, end table row
233.  Write start table row, start table data, start form that runs function 'finish'
      when submitted
234.  Write "Finish" button to run function 'finish' when clicked
235.  Write end form, end table data, end table row, and end table
236.  Write end DIV tag
237.  Write end DIV tag
238.  Blank line
239.  finish ();
240.  Run function 'refocus' every 500 milliseconds
241.  Blank line
242.  End CDATA
```

243. End JavaScript
244. Blank line
245. End DIV
246. Blank line
247. Begin PHP code
248. Include ‘footer.inc’ to draw the bottom part of the page
249. End PHP code
250. Blank line
251. End DIV
252. Blank line
253. Line break
254. Blank line
255. Begin PHP code
256. Blank line
257. End IF statement and begin ELSE statement if the variables are not present or SESSION is not set properly
258. Blank line
259. Include ‘header.inc’ to draw the header of the page
260. Include ‘badpage.inc’ to add the page script that shows if a user is not permitted to view the page
261. Blank line
262. End ELSE
263. End PHP code

Website Screenshots

SEE IT → DESCRIBE IT → SUBMIT IT

ICON STUDY . COM

Begin

Instructions

Here's how it works: You will complete a short questionnaire so we can know some important facts about you. It will also let us know if you are eligible to take the survey.

Next, we will show you a series of icons. You will be asked to type what you think the icon represents. You may submit as many answers as you wish. There are no right or wrong responses. There are 50 icons, and the survey should take about 10 to 15 minutes. Questions? Email us at info@iconstudy.com

Win a $15 Barnes and Noble Gift Certificate!

We are giving away 6 certificates to participants. If you take our survey, you will be automatically entered in the drawing. Winners will receive an email from iconstudy.com after the study concludes. The cards are usable in-store and online at www.barnesandnoble.com

The first drawing is scheduled for **July 10, 2009**.

BARNES&NOBLE
BOOKSELLERS

Send this survey to others

Your name or email:

Type the recipient email addresses below, separating each one with a comma:

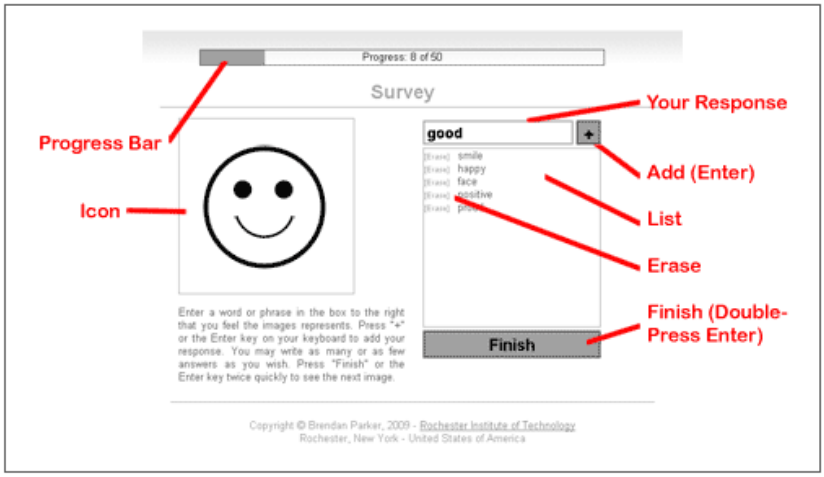
Include a brief message:

Send

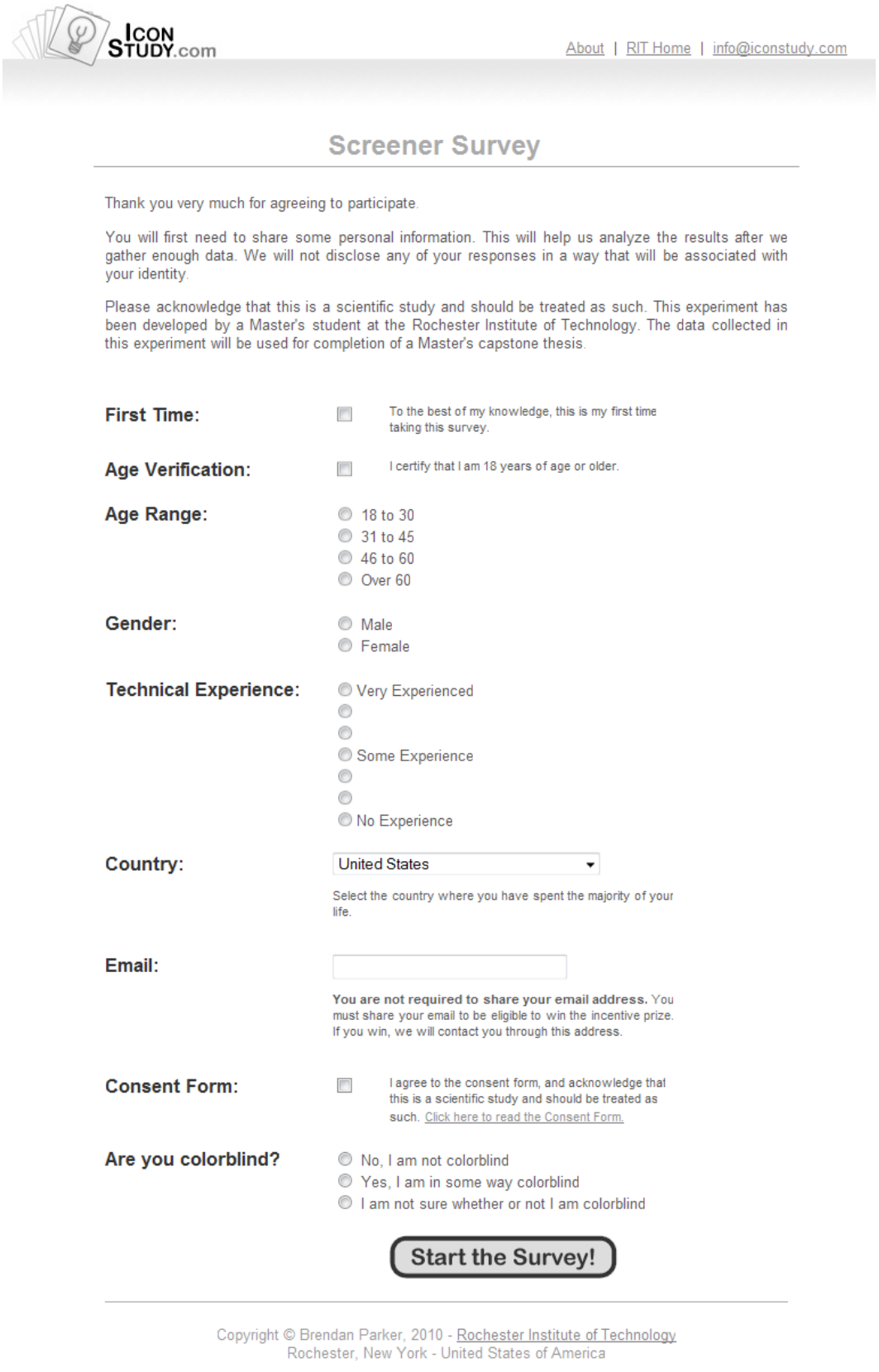
ICON STUDY.com

About | RIT Home | info@iconstudy.com

Instructions



- When you start the survey, an icon will appear.
- On the right is a box in which you will write what you believe the icon represents. After you write a word or phrase in the box, click the "+" button or press the Enter (or Return) key on your keyboard. This will add your answer to your list.
- Your answer will show in the large response box. The response box lists all your answers. If you want to remove a submitted response, press the Erase button adjacent to the response to remove that response.
- You may submit as many responses as you would like. When you feel you have added enough, press the Finish button or press the Enter (or Return) key on your keyboard twice quickly.
- When you press finish, your responses will clear. New icons will appear until you have completed the study. The Progress Bar at the top of the screen shows how close you are to finishing the survey.
- You will need to fill out a short questionnaire beforehand so we know more about you. Click here to start the survey.



ICON STUDY.com

About | RIT Home | info@iconstudy.com

Screener Survey

Thank you very much for agreeing to participate.

You will first need to share some personal information. This will help us analyze the results after we gather enough data. We will not disclose any of your responses in a way that will be associated with your identity.

Please acknowledge that this is a scientific study and should be treated as such. This experiment has been developed by a Master's student at the Rochester Institute of Technology. The data collected in this experiment will be used for completion of a Master's capstone thesis.

First Time: ☐ To the best of my knowledge, this is my first time taking this survey.

Age Verification: ☐ I certify that I am 18 years of age or older.

Age Range:
- ○ 18 to 30
- ○ 31 to 45
- ○ 46 to 60
- ○ Over 60

Gender:
- ○ Male
- ○ Female

Technical Experience:
- ○ Very Experienced
- ○
- ○
- ○ Some Experience
- ○
- ○
- ○ No Experience

Country: United States

Select the country where you have spent the majority of your life.

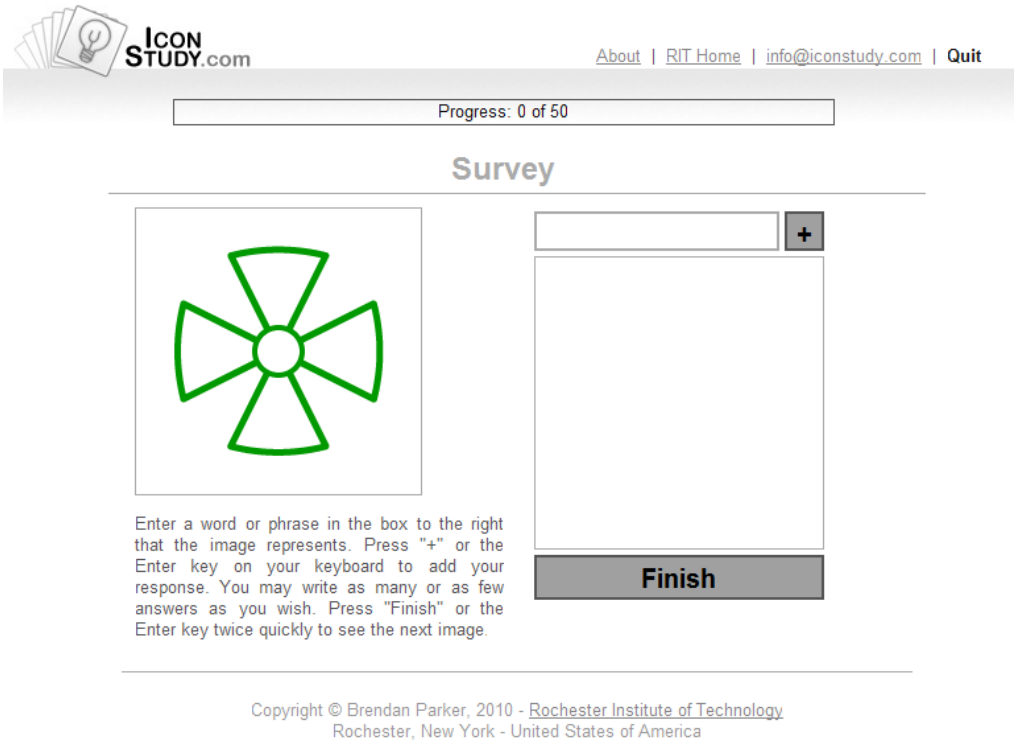
Email:

You are not required to share your email address. You must share your email to be eligible to win the incentive prize. If you win, we will contact you through this address.

Consent Form: ☐ I agree to the consent form, and acknowledge that this is a scientific study and should be treated as such. Click here to read the Consent Form.

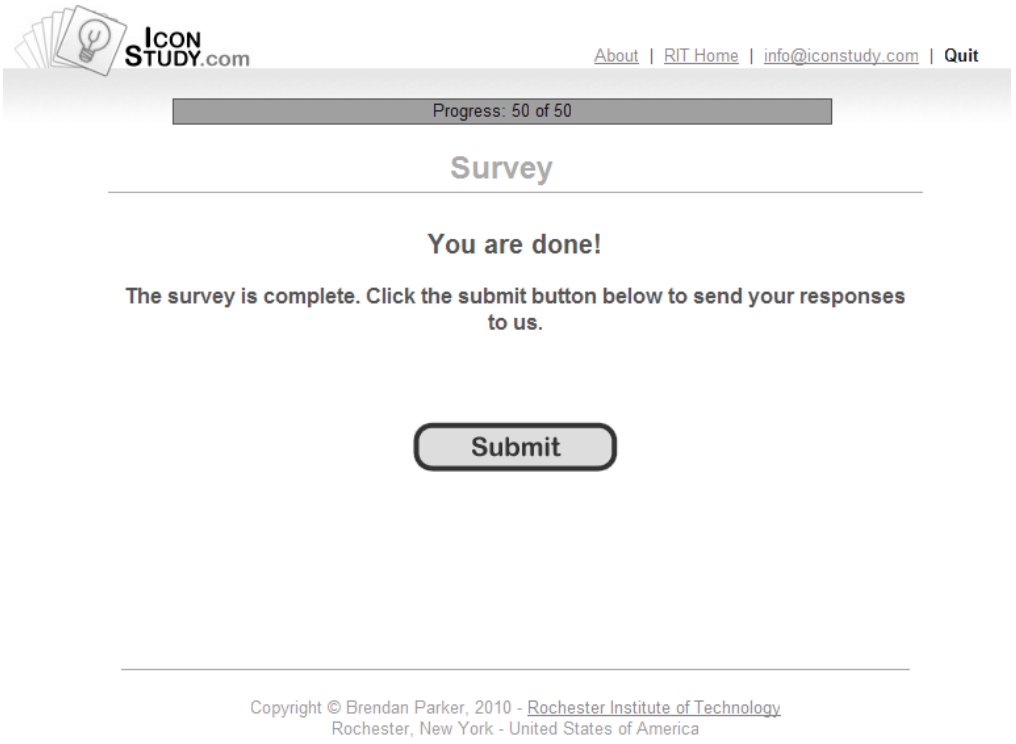
Are you colorblind?
- ○ No, I am not colorblind
- ○ Yes, I am in some way colorblind
- ○ I am not sure whether or not I am colorblind

Start the Survey!


ICON STUDY.com
About | RIT Home | info@iconstudy.com | Quit
Progress: 0 of 50
Survey
+
Enter a word or phrase in the box to the right that the image represents. Press "+" or the Enter key on your keyboard to add your response. You may write as many or as few answers as you wish. Press "Finish" or the Enter key twice quickly to see the next image.
Finish
Copyright © Brendan Parker, 2010 - Rochester Institute of Technology
Rochester, New York - United States of America


ICON STUDY.com
About | RIT Home | info@iconstudy.com | Quit
Progress: 29 of 50
Survey
+
[Erase] key
[Erase] lock
[Erase] tractor
Enter a word or phrase in the box to the right that the image represents. Press "+" or the Enter key on your keyboard to add your response. You may write as many or as few answers as you wish. Press "Finish" or the Enter key twice quickly to see the next image.
Finish
Copyright © Brendan Parker, 2010 - Rochester Institute of Technology
Rochester, New York - United States of America


ICON STUDY.com
About | RIT Home | info@iconstudy.com | Quit
Progress: 29 of 50
Survey
key
+
You have already added that response. You cannot submit the same term more than once. [close]
Enter a word or phrase in the box to the right that the image represents. Press "+" or the Enter key on your keyboard to add your response. You may write as many or as few answers as you wish. Press "Finish" or the Enter key twice quickly to see the next image.
Finish
Copyright © Brendan Parker, 2010 - Rochester Institute of Technology
Rochester, New York - United States of America


ICON STUDY.com
About | RIT Home | info@iconstudy.com | Quit
Progress: 50 of 50
Survey
You are done!
The survey is complete. Click the submit button below to send your responses to us.
Submit
Copyright © Brendan Parker, 2010 - Rochester Institute of Technology
Rochester, New York - United States of America

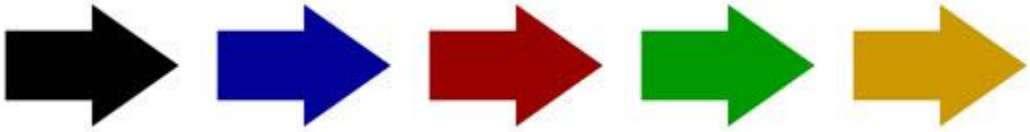
Appendix C – Icons and Data

Icon Library

Below is a collection of every icon and color variation used in this experiment.

Icon #00

Icon #01



Icon #02

Icon #03

Icon #04

Icon #05

Icon #06

Icon #07

Icon #08

Icon #09

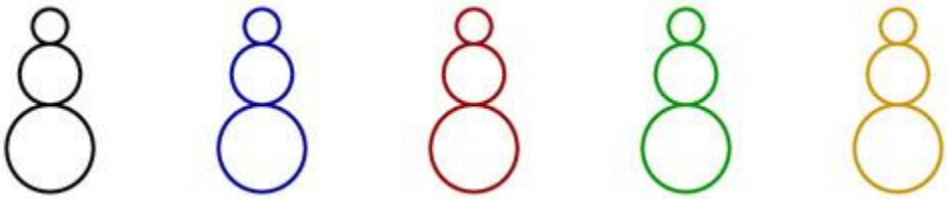
Icon #10

Icon #11

Icon #12

Icon #13

Icon #14



Icon #15

Icon #16

Icon #17

Icon #18

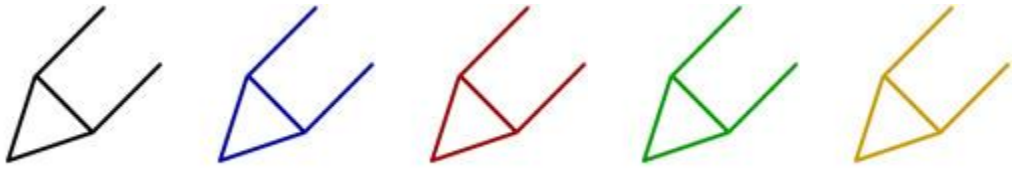
Icon #19

Icon #20

Icon #21

Icon #22

Icon #23



Icon #24

Icon #25

Icon #26

Icon #27

Icon #28

Icon #29

Icon #30

Icon #31

Icon #32

Icon #33

Icon #34

Icon #35

Icon #36

Icon #37

Icon #38

Icon #39

Icon #40

Icon #41

Icon #42

Icon #43

Icon #44

Icon #45

Icon #46

Icon #47

Icon #48

Icon #49

Participant Demographic Information (for First 10 Participants)

uID	partID	date	age	gender	techexp	country	email	colorblind
1	409888	June 16, 2009, 6:17	46to60	male	2	usa	noemail	yes
2	919575	June 17, 2009, 7:27	31to45	male	4	usa	<removed>	no
3	378918	June 17, 2009, 8:00	31to45	female	2	usa	<removed>	no
4	105932	June 17, 2009, 8:31	31to45	male	3	usa	<removed>	no
5	499709	June 17, 2009, 9:55	46to60	male	1	usa	<removed>	no
6	153706	June 17, 2009, 11:31	18to30	female	3	usa	<removed>	no
7	521328	June 17, 2009, 11:57	31to45	male	2	usa	noemail	no
8	12938	June 17, 2009, 1:55	46to60	female	4	usa	<removed>	no
9	658083	June 17, 2009, 2:19	31to45	male	2	usa	noemail	no
10	353176	June 17, 2009, 2:23	18to30	female	4	usa	<removed>	no

Table 15 – Participant Demographic Information

The data above shows the demographic information for the first 10 participants. "uID" represents the unique number which increases by 1 when a new participant is added. "partID" is the participant ID which is used to match the participant's demographic information to the responses in another database. These numbers will match. The "date" column denotes when the data was submitted. "age" is the range in which the participant claimed his or her age was included. The "gender" column states which gender the participant selected to represent him or herself. The "techexp" is the subjective interpretation of one's own technical experience. The "country" column

is the country the user selected from the dropdown menu where the participant has spent the most time. The "email," which has been removed for privacy, is the email address the participant provided. The "colorblind" column stores the participant's response to whether or not the participant is colorblind.

Response Data (for Icon #00)

uID	partID	date	num	color	initData	newData
6561	270680	June 20, 2009, 6:07 pm	0	4	balloon	balloon
4722	36028	June 19, 2009, 12:23 pm	0	1	balloon	balloon
20431	527960	June 27, 2009, 5:02 pm	0	4	balance	balance
20988	462613	July 2, 2009, 7:27 am	0	1	attache ring	ring
5552	661688	June 20, 2009, 1:47 am	0	2	Apple corer	corer
2078	974316	June 18, 2009, 10:00 am	0	2	ornament	ornament
24313	198587	July 10, 2009, 12:10 am	0	2	alarm clock	clock
14825	122088	June 22, 2009, 6:56 pm	0	1	stopwatch	stopwatch
9045	954010	June 22, 2009, 8:23 am	0	1	Christmas tree ornamemt	ornament
8337	756452	June 21, 2009, 10:30 pm	0	4	bomb Bugs bunny	bomb
16413	790291	June 23, 2009, 10:27 am	0	3	bomb	bomb
15078	854979	June 22, 2009, 9:28 pm	0	5	bomb	bomb
9046	954010	June 22, 2009, 8:23 am	0	1	bomb	bomb
13896	632794	June 22, 2009, 3:12 pm	0	2	balloon	balloon
17743	600603	June 23, 2009, 9:31 pm	0	4	balloon	balloon
19620	400177	June 25, 2009, 5:53 pm	0	5	balloon	balloon
3434	545292	June 18, 2009, 5:12 pm	0	2	basketball hoop	hoop
2530	353566	June 18, 2009, 1:54 pm	0	1	beaker	beaker
16900	775144	June 23, 2009, 12:00 pm	0	1	beaker	beaker
17182	198714	June 23, 2009, 3:30 pm	0	1	beaker	beaker
9478	895327	June 22, 2009, 8:30 am	0	2		
10787	536984	June 22, 2009, 9:53 am	0	5	bell	bell
2833	899452	June 18, 2009, 3:07 pm	0	1	black bomb	bomb
21170	226300	July 2, 2009, 10:08 am	0	3	blank	blank
255	105932	June 17, 2009, 8:31 am	0	4	bomb	bomb
428	153706	June 17, 2009, 11:31 am	0	3	bomb	bomb
825	880161	June 17, 2009, 5:12 pm	0	5	bomb	bomb
1051	88013	June 17, 2009, 9:41 pm	0	1	bomb	bomb
1504	944461	June 18, 2009, 2:10 am	0	4	Bomb	bomb
1553	629927	June 18, 2009, 2:16 am	0	2	Bomb	bomb
1874	18404	June 18, 2009, 8:47 am	0	2	Bomb	bomb
1996	329413	June 18, 2009, 9:58 am	0	1	bomb	bomb
2326	624128	June 18, 2009, 11:50 am	0	3	bomb	bomb
2528	353566	June 18, 2009, 1:54 pm	0	1	bomb	bomb
2618	982844	June 18, 2009, 2:40 pm	0	1	bomb	bomb
2941	655130	June 18, 2009, 3:42 pm	0	3	bomb	bomb
2991	598683	June 18, 2009, 3:57 pm	0	2	bomb	bomb
3360	473062	June 18, 2009, 4:49 pm	0	5	bomb	bomb
3991	533742	June 18, 2009, 9:55 pm	0	2	bomb	bomb
4101	496450	June 19, 2009, 12:02 am	0	3	bomb	bomb
4244	633324	June 19, 2009, 12:14 am	0	3	Bomb	bomb
4606	460050	June 19, 2009, 12:08 pm	0	5	Bomb	bomb
4822	13935	June 19, 2009, 12:27 pm	0	2	bomb	bomb
4906	116348	June 19, 2009, 1:47 pm	0	1	bomb	bomb
5087	650078	June 19, 2009, 2:50 pm	0	3	bomb	bomb
5355	798509	June 19, 2009, 7:23 pm	0	5	bomb	bomb
5544	661688	June 20, 2009, 1:47 am	0	2	Bomb	bomb
5883	776487	June 20, 2009, 7:51 am	0	3	bomb	bomb
5942	693742	June 20, 2009, 9:14 am	0	4	bomb	bomb
6121	634654	June 20, 2009, 1:42 pm	0	4	bomb	bomb
6465	515220	June 20, 2009, 5:08 pm	0	3	bomb	bomb
7720	527122	June 21, 2009, 7:31 am	0	4	bomb	bomb
8032	808986	June 21, 2009, 3:59 pm	0	3	bomb	bomb
8408	940559	June 22, 2009, 6:38 am	0	1	bomb	bomb

8554	702982	June 22, 2009, 8:08 am	0	5	bomb	bomb
9111	660074	June 22, 2009, 8:24 am	0	5	bomb	bomb
9314	732822	June 22, 2009, 8:26 am	0	2	bomb	bomb
9476	895327	June 22, 2009, 8:30 am	0	2		
9586	456860	June 22, 2009, 8:34 am	0	2	bomb	bomb
9741	263882	June 22, 2009, 8:40 am	0	3	bomb	bomb
9816	587869	June 22, 2009, 8:44 am	0	3	bomb	bomb
10034	850998	June 22, 2009, 8:47 am	0	5	bomb	bomb
10370	590208	June 22, 2009, 9:02 am	0	4	bomb	bomb
10528	776288	June 22, 2009, 9:16 am	0	3	bomb	bomb
10616	765893	June 22, 2009, 9:24 am	0	3	bomb	bomb
11104	713816	June 22, 2009, 9:59 am	0	5	bomb	bomb
11257	143059	June 22, 2009, 10:02 am	0	4	bomb	bomb
11361	827981	June 22, 2009, 10:12 am	0	1	bomb	bomb
11451	533946	June 22, 2009, 10:15 am	0	3	Bomb	bomb
12275	285183	June 22, 2009, 11:27 am	0	5	bomb	bomb
12547	949450	June 22, 2009, 11:42 am	0	4	bomb	bomb
13128	306126	June 22, 2009, 1:03 pm	0	5	bomb	bomb
13574	29126	June 22, 2009, 2:20 pm	0	4	bomb	bomb
13816	966180	June 22, 2009, 2:40 pm	0	4	Bomb	bomb
13895	632794	June 22, 2009, 3:12 pm	0	2	bomb	bomb
14056	551142	June 22, 2009, 4:08 pm	0	5	bomb	bomb
14406	790997	June 22, 2009, 5:21 pm	0	4	Bomb	bomb
14626	456249	June 22, 2009, 6:26 pm	0	1	bomb	bomb
14676	987911	June 22, 2009, 6:30 pm	0	1	Bomb	bomb
14878	450094	June 22, 2009, 8:05 pm	0	2	bomb	bomb
15005	572980	June 22, 2009, 9:07 pm	0	2	bomb	bomb
15757	18615	June 23, 2009, 1:49 am	0	1	bomb	bomb
15830	908339	June 23, 2009, 8:11 am	0	4	Bomb	bomb
15906	94405	June 23, 2009, 8:31 am	0	2	bomb	bomb
16290	940217	June 23, 2009, 10:12 am	0	4	Bomb	bomb
16899	775144	June 23, 2009, 12:00 pm	0	1	bomb	bomb
17005	285580	June 23, 2009, 1:55 pm	0	3	bomb	bomb
17180	198714	June 23, 2009, 3:30 pm	0	1	bomb	bomb
17309	911596	June 23, 2009, 4:29 pm	0	1	bomb	bomb
17481	398295	June 23, 2009, 6:35 pm	0	3		
17618	245159	June 23, 2009, 7:43 pm	0	2	Bomb	bomb
17822	954875	June 23, 2009, 10:04 pm	0	1	bomb	bomb
17937	415382	June 24, 2009, 7:57 am	0	2	bomb	bomb
18079	292320	June 24, 2009, 9:25 am	0	5	bomb	bomb
18277	545154	June 24, 2009, 2:11 pm	0	2	bomb	bomb
18392	715165	June 24, 2009, 2:20 pm	0	2	bomb	bomb
18571	113277	June 24, 2009, 2:40 pm	0	2	bomb	bomb
18632	905057	June 24, 2009, 3:53 pm	0	3	bomb	bomb
18733	308871	June 24, 2009, 4:08 pm	0	3	bomb	bomb
18790	817010	June 24, 2009, 9:41 pm	0	5		
18987	480849	June 25, 2009, 5:52 am	0	3	bomb	bomb
19051	730845	June 25, 2009, 9:08 am	0	3	bomb	bomb
19370	329097	June 25, 2009, 4:09 pm	0	4	Bomb	bomb
19458	235054	June 25, 2009, 5:40 pm	0	2	bomb	bomb
19518	186569	June 25, 2009, 5:53 pm	0	1	bomb	bomb
19617	400177	June 25, 2009, 5:53 pm	0	5	bomb	bomb
20023	911628	June 26, 2009, 3:26 pm	0	2	bomb	bomb
20107	10321	June 27, 2009, 4:55 pm	0	4	bomb	bomb
20231	356014	June 27, 2009, 4:57 pm	0	5	bomb	bomb
20317	245819	June 27, 2009, 4:58 pm	0	2	bomb	bomb
21436	45606	July 3, 2009, 3:36 pm	0	1	bomb	bomb
21596	722029	July 5, 2009, 12:49 am	0	5	bomb	bomb
22156	711409	July 5, 2009, 1:01 am	0	3	bomb	bomb
22950	493636	July 7, 2009, 4:41 pm	0	1	bomb	bomb
23071	628909	July 8, 2009, 9:19 am	0	5	Bomb	bomb
23130	810786	July 8, 2009, 5:17 pm	0	4	bomb	bomb
23301	661422	July 8, 2009, 5:44 pm	0	3	Bomb	bomb
23391	522801	July 8, 2009, 6:17 pm	0	2	bomb	bomb
23673	713768	July 9, 2009, 10:01 am	0	5	bomb	bomb
23779	177061	July 9, 2009, 12:59 pm	0	2	bomb	bomb

23845	158049	July 9, 2009, 1:27 pm	0	1	bomb	bomb
24040	459791	July 9, 2009, 4:53 pm	0	3	BOMB	bomb
24104	872026	July 9, 2009, 4:53 pm	0	1	bomb	bomb
24727	217809	July 10, 2009, 10:59 pm	0	2	bomb	bomb
24877	101453	July 13, 2009, 7:41 pm	0	5	bomb	bomb
24966	609478	July 16, 2009, 9:25 pm	0	2	bomb	bomb
25053	624463	July 26, 2009, 9:01 pm	0	3	bomb	bomb
23622	288503	July 9, 2009, 4:46 am	0	3	bomb risk	risk
13223	198403	June 22, 2009, 1:07 pm	0	1	bomb grenade	grenade
4909	116348	June 19, 2009, 1:47 pm	0	1	bomber man	bomber man
73	919575	June 17, 2009, 7:27 am	0	4	bottle	bottle
655	353176	June 17, 2009, 2:23 pm	0	3	bottle	bottle
4351	995834	June 19, 2009, 10:34 am	0	1	Bottle	bottle
13402	487623	June 22, 2009, 2:03 pm	0	1	bottle	bottle
14054	551142	June 22, 2009, 4:08 pm	0	5	bottle	bottle
14530	755795	June 22, 2009, 5:58 pm	0	4	bottle	bottle
19314	878035	June 25, 2009, 2:57 pm	0	5		
19520	186569	June 25, 2009, 5:53 pm	0	1	bottle	bottle
20108	10321	June 27, 2009, 4:55 pm	0	4	bottle	bottle
20640	206071	June 30, 2009, 8:42 am	0	2	bottle	bottle
22615	98966	July 5, 2009, 1:16 am	0	4	Bottle	bottle
24728	217809	July 10, 2009, 10:59 pm	0	2	bottle	bottle
1806	780190	June 18, 2009, 7:02 am	0	5	bottle stopper	stopper
13766	45101	June 22, 2009, 2:39 pm	0	4	bottled	bottle
7981	9552	June 21, 2009, 3:53 pm	0	5	Bubble hoop	hoop
6627	513340	June 20, 2009, 6:22 pm	0	3	bulb	bulb
12598	422273	June 22, 2009, 11:53 am	0	5		
1807	780190	June 18, 2009, 7:02 am	0	5	button	button
2993	598683	June 18, 2009, 3:57 pm	0	2	button	button
22056	780335	July 5, 2009, 1:01 am	0	2	button	button
1669	91071	June 18, 2009, 4:57 am	0	1	canister	canister
15141	366226	June 22, 2009, 10:48 pm	0	5	cannon	cannon
496	521328	June 17, 2009, 11:57 am	0	1	canteen	canteen
973	460023	June 17, 2009, 8:30 pm	0	4	canteen	canteen
1554	629927	June 18, 2009, 2:16 am	0	2	Canteen	canteen
2763	467572	June 18, 2009, 3:03 pm	0	4	canteen	canteen
3250	17093	June 18, 2009, 4:42 pm	0	2	canteen	canteen
5551	661688	June 20, 2009, 1:47 am	0	2	Canteen	canteen
7335	816531	June 21, 2009, 2:50 am	0	5	canteen	canteen
8687	623122	June 22, 2009, 8:16 am	0	4	canteen	canteen
10320	608769	June 22, 2009, 9:01 am	0	2	canteen	canteen
12172	110428	June 22, 2009, 11:24 am	0	5	canteen	canteen
12470	832640	June 22, 2009, 11:37 am	0	5	canteen	canteen
12826	534094	June 22, 2009, 12:20 pm	0	3	canteen	canteen
13297	389751	June 22, 2009, 1:45 pm	0	3	canteen	canteen
13678	501612	June 22, 2009, 2:21 pm	0	3	canteen	canteen
14411	790997	June 22, 2009, 5:21 pm	0	4	Canteen	canteen
14755	996534	June 22, 2009, 6:53 pm	0	2	canteen	canteen
15140	366226	June 22, 2009, 10:48 pm	0	5	canteen	canteen
15283	483998	June 23, 2009, 12:11 am	0	3	canteen	canteen
16703	453873	June 23, 2009, 10:39 am	0	4	canteen	canteen
18633	905057	June 24, 2009, 3:53 pm	0	3	canteen	canteen
18791	817010	June 24, 2009, 9:41 pm	0	5		
19238	286011	June 25, 2009, 11:08 am	0	1	canteen	canteen
20232	356014	June 27, 2009, 4:57 pm	0	5	canteen	canteen
20319	245819	June 27, 2009, 4:58 pm	0	2	canteen	canteen
20516	674318	June 28, 2009, 7:51 pm	0	2		
22157	711409	July 5, 2009, 1:01 am	0	3	canteen	canteen
22446	810458	July 5, 2009, 1:14 am	0	2	canteen	canteen
23072	628909	July 8, 2009, 9:19 am	0	5	canteen	canteen
24878	101453	July 13, 2009, 7:41 pm	0	5	canteen	canteen
8082	506435	June 21, 2009, 5:31 pm	0	1	canteen	canteen
19519	186569	June 25, 2009, 5:53 pm	0	1	canteen	canteen
11559	5724	June 22, 2009, 10:23 am	0	1	canteen	canteen
7014	666160	June 21, 2009, 1:25 am	0	3	cartoon bomb	bomb
972	460023	June 17, 2009, 8:30 pm	0	4	ceiling light	light

5548	661688	June 20, 2009, 1:47 am	0	2	Ceiling light	light
3199	810371	June 18, 2009, 4:19 pm	0	5	ceiling light	light
4605	460050	June 19, 2009, 12:08 pm	0	5	Chemical	chemical
7525	403292	June 21, 2009, 4:11 am	0	4	chemical flask liquids	flask
187	378918	June 17, 2009, 8:00 am	0	4	Chemistry	chemical
2992	598683	June 18, 2009, 3:57 pm	0	2	chimney	chimney
10968	985665	June 22, 2009, 9:56 am	0	5	christmas	christmas
3926	137754	June 18, 2009, 9:32 pm	0	5	christmas bulb	bulb
18015	556911	June 24, 2009, 9:10 am	0	2	christmas bulb	bulb
20987	462613	July 2, 2009, 7:27 am	0	1	christmas bulb	bulb
21699	410607	July 5, 2009, 12:51 am	0	4	christmas bulb	bulb
24462	606135	July 10, 2009, 5:01 am	0	2	Christmas bulb	bulb
17123	809195	June 23, 2009, 2:29 pm	0	2	christmas bulb light bulb	bulb
17123	809195	June 23, 2009, 2:29 pm	0	2	christmas bulb light bulb	bulb
596	658083	June 17, 2009, 2:19 pm	0	1	Christmas ornament	ornament
2215	189172	June 18, 2009, 11:30 am	0	3	christmas ornament	ornament
13484	755065	June 22, 2009, 2:11 pm	0	2	Christmas Ornament	ornament
24041	459791	July 9, 2009, 4:53 pm	0	3	CHRISTMAS ORNAMENT	ornament
24154	487008	July 9, 2009, 5:03 pm	0	1	Christmas ornament	ornament
24726	217809	July 10, 2009, 10:59 pm	0	2	christmas ornament	ornament
10966	985665	June 22, 2009, 9:56 am	0	5	circle	circle
21802	853711	July 5, 2009, 12:52 am	0	2	clasp	clasp
8152	462771	June 21, 2009, 6:03 pm	0	5	class	class
1050	88013	June 17, 2009, 9:41 pm	0	1	clock	clock
2134	994279	June 18, 2009, 11:20 am	0	3	Clock	clock
3483	876736	June 18, 2009, 5:29 pm	0	5	clock	clock
6202	576793	June 20, 2009, 2:11 pm	0	2		
8876	868856	June 22, 2009, 8:21 am	0	1	clock	clock
9220	102122	June 22, 2009, 8:25 am	0	1	Clock	clock
10462	276925	June 22, 2009, 9:11 am	0	5	clock	clock
12738	402008	June 22, 2009, 12:09 pm	0	5	clock	clock
13573	29126	June 22, 2009, 2:20 pm	0	4	clock	clock
14179	771126	June 22, 2009, 4:50 pm	0	5	clock	clock
16496	485626	June 23, 2009, 10:38 am	0	4	clock	clock
18906	640603	June 24, 2009, 9:42 pm	0	5	Clock	clock
23132	810786	July 8, 2009, 5:17 pm	0	4	clock	clock
23982	882068	July 9, 2009, 4:53 pm	0	4	clock	clock
15287	483998	June 23, 2009, 12:11 am	0	3	common	common
21383	59173	July 3, 2009, 1:49 pm	0	1	compass time	compass
21383	59173	July 3, 2009, 1:49 pm	0	1	compass time	time
8881	868856	June 22, 2009, 8:21 am	0	1	complete quickly	complete
10874	290381	June 22, 2009, 9:55 am	0	3	condition	condition
2994	598683	June 18, 2009, 3:57 pm	0	2	conductor	conduct
5944	693742	June 20, 2009, 9:14 am	0	4	container	container
12277	285183	June 22, 2009, 11:27 am	0	5	container	container
15284	483998	June 23, 2009, 12:11 am	0	3	cooling	cooling
8153	462771	June 21, 2009, 6:03 pm	0	5	dependency	dependent
22951	493636	July 7, 2009, 4:41 pm	0	1	detonation	detonate
3992	533742	June 18, 2009, 9:55 pm	0	2	diamond ring	ring
23674	713768	July 9, 2009, 10:01 am	0	5	disco ball	ball
16706	453873	June 23, 2009, 10:39 am	0	4	drink	drink
18279	545154	June 24, 2009, 2:11 pm	0	2	engagement ring	ring
711	389470	June 17, 2009, 4:32 pm	0	3	experiment	experiment
15907	94405	June 23, 2009, 8:31 am	0	2	explode	explode
11171	493879	June 22, 2009, 10:00 am	0	1	explosion	explode
6882	755984	June 21, 2009, 1:19 am	0	2	Female perfume	perfume
8483	109022	June 22, 2009, 7:51 am	0	3	fill here	fill
13023	599198	June 22, 2009, 12:57 pm	0	4	fire alarm	alarm
17308	911596	June 23, 2009, 4:29 pm	0	1	fishbowl	fishbowl
74	919575	June 17, 2009, 7:27 am	0	4	flask	flask
189	378918	June 17, 2009, 8:00 am	0	4	Flask	flask
321	499709	June 17, 2009, 9:55 am	0	2	flask	flask
497	521328	June 17, 2009, 11:57 am	0	1	flask	flask
1724	702683	June 18, 2009, 6:18 am	0	4	flask	flask
2135	994279	June 18, 2009, 11:20 am	0	3	Flask	flask
2527	353566	June 18, 2009, 1:54 pm	0	1	flask	flask

5302	25156	June 19, 2009, 6:42 pm	0	5	flask	flask
5473	64118	June 20, 2009, 1:02 am	0	4	flask	flask
6628	513340	June 20, 2009, 6:22 pm	0	3	flask	flask
8623	281106	June 22, 2009, 8:09 am	0	1	flask	flask
14410	790997	June 22, 2009, 5:21 pm	0	4	Flask	flask
16704	453873	June 23, 2009, 10:39 am	0	4	flask	flask
21749	314016	July 5, 2009, 12:52 am	0	1	flask	flask
22614	98966	July 5, 2009, 1:16 am	0	4	Flask	flask
5547	661688	June 20, 2009, 1:47 am	0	2	Florence Flask	flask
16145	428450	June 23, 2009, 9:30 am	0	1	frag grenade	grenade
23780	177061	July 9, 2009, 12:59 pm	0	2	submarine	submarine
925	863998	June 17, 2009, 7:40 pm	0	1	fuel tank	tank
23516	6458	July 8, 2009, 9:04 pm	0	3	fuel tank	tank
18394	715165	June 24, 2009, 2:20 pm	0	2	fullerene chimney	chimney
4908	116348	June 19, 2009, 1:47 pm	0	1	game	game
710	389470	June 17, 2009, 4:32 pm	0	3	gas	gas
4723	36028	June 19, 2009, 12:23 pm	0	1	gaseous matter	matter
10873	290381	June 22, 2009, 9:55 am	0	3	gate	gate
6884	755984	June 21, 2009, 1:19 am	0	2	gernade	grenade
6626	513340	June 20, 2009, 6:22 pm	0	3	globe	globe
14180	771126	June 22, 2009, 4:50 pm	0	5	golden	gold
2529	353566	June 18, 2009, 1:54 pm	0	1	granade	grenade
3558	586634	June 18, 2009, 6:45 pm	0	4		
1289	786453	June 18, 2009, 1:04 am	0	5	grenade	grenade
1723	702683	June 18, 2009, 6:18 am	0	4	grenade	grenade
2377	493789	June 18, 2009, 11:54 am	0	1	grenade	grenade
2619	982844	June 18, 2009, 2:40 pm	0	1	grenade	grenade
3684	894721	June 18, 2009, 7:15 pm	0	1	grenade	grenade
4245	633324	June 19, 2009, 12:14 am	0	3	Grenade	grenade
7770	486886	June 21, 2009, 7:51 am	0	2	grenade	grenade
8688	623122	June 22, 2009, 8:16 am	0	4	grenade	grenade
11170	493879	June 22, 2009, 10:00 am	0	1	grenade	grenade
11450	533946	June 22, 2009, 10:15 am	0	3	Grenade	grenade
11724	185973	June 22, 2009, 10:35 am	0	4	grenade	grenade
11968	477050	June 22, 2009, 10:46 am	0	1	grenade	grenade
12173	110428	June 22, 2009, 11:24 am	0	5	grenade	grenade
14309	436038	June 22, 2009, 4:50 pm	0	4	grenade	grenade
14407	790997	June 22, 2009, 5:21 pm	0	4	Grenade	grenade
14877	450094	June 22, 2009, 8:05 pm	0	2	grenade	grenade
15139	366226	June 22, 2009, 10:48 pm	0	5	grenade	grenade
17483	398295	June 23, 2009, 6:35 pm	0	3		
18278	545154	June 24, 2009, 2:11 pm	0	2	grenade	grenade
19150	829265	June 25, 2009, 10:27 am	0	4	grenade	grenade
19843	631394	June 26, 2009, 9:43 am	0	2	grenade	grenade
13986	938251	June 22, 2009, 3:37 pm	0	2	grinade	grenade
4823	13935	June 19, 2009, 12:27 pm	0	2	hand grenade	grenade
1239	681023	June 18, 2009, 12:53 am	0	2	handle	handle
7163	343379	June 21, 2009, 2:22 am	0	3	hanging globe	globe
25054	624463	July 26, 2009, 9:01 pm	0	3	hazardous material	material
5943	693742	June 20, 2009, 9:14 am	0	4	holding	holding
18393	715165	June 24, 2009, 2:20 pm	0	2	holy hand grenade	grenade
5546	661688	June 20, 2009, 1:47 am	0	2	Hose clamp	clamp
13485	755065	June 22, 2009, 2:11 pm	0	2	House top world	house
22449	810458	July 5, 2009, 1:14 am	0	2	House north pole	house
19906	820218	June 26, 2009, 2:17 pm	0	2		
24730	217809	July 10, 2009, 10:59 pm	0	2	igloo	igloo
5205	90818	June 19, 2009, 4:37 pm	0	3	Instrument	instrument
15286	483998	June 23, 2009, 12:11 am	0	3	invigorating	invigorate
21877	831769	July 5, 2009, 12:56 am	0	4	Japanese Granade	grenade
1152	877704	June 17, 2009, 11:18 pm	0	5	jug	jug
709	389470	June 17, 2009, 4:32 pm	0	3	laboratory	laboratory
23578	538581	July 8, 2009, 9:28 pm	0	3	large jar carried camels	jar
23578	538581	July 8, 2009, 9:28 pm	0	3	large jar carried camels	camel
15601	276468	June 23, 2009, 12:50 am	0	3	large pipe planet	pipe
22817	445049	July 7, 2009, 4:36 pm	0	3	light	light
24226	709351	July 9, 2009, 11:01 pm	0	1	light dome	dome

926	863998	June 17, 2009, 7:40 pm	0	1	light globe	globe
9657	391108	June 22, 2009, 8:36 am	0	5	piggy bank savings	save
21801	853711	July 5, 2009, 12:52 am	0	2	lock	lock
12045	655617	June 22, 2009, 10:56 am	0	3	bottle gas cylinder	bottle
12045	655617	June 22, 2009, 10:56 am	0	3	bottle gas cylinder	gas
12045	655617	June 22, 2009, 10:56 am	0	3	bottle gas cylinder	cylinder
9817	587869	June 22, 2009, 8:44 am	0	3	magnifying glass	magnifying glass
3681	894721	June 18, 2009, 7:15 pm	0	1	mana potion	potion
3873	410334	June 18, 2009, 9:23 pm	0	5	mario	mario
6739	711160	June 21, 2009, 12:12 am	0	2	mechincal thingie	thing
14409	790997	June 22, 2009, 5:21 pm	0	4	Melon	melon
7648	505712	June 21, 2009, 5:12 am	0	4		
22766	108438	July 5, 2009, 1:05 pm	0	2		
13292	926430	June 22, 2009, 1:13 pm	0	1		
16790	726083	June 23, 2009, 10:46 am	0	2		
10115	555285	June 22, 2009, 8:47 am	0	1		
22280	217977	July 5, 2009, 1:02 am	0	3	old style bomb cartoons	bomb
13767	45101	June 22, 2009, 2:39 pm	0	4	tanked	tank
427	153706	June 17, 2009, 11:31 am	0	3	ornament	ornament
4507	437893	June 19, 2009, 11:48 am	0	5	ornament	ornament
5352	798509	June 19, 2009, 7:23 pm	0	5	ornament	ornament
7424	677930	June 21, 2009, 3:05 am	0	3	ornament	ornament
10967	985665	June 22, 2009, 9:56 am	0	5	ornament	ornament
11661	853255	June 22, 2009, 10:25 am	0	5	ornament	ornament
15142	366226	June 22, 2009, 10:48 pm	0	5	ornament	ornament
20571	278167	June 28, 2009, 8:46 pm	0	5	ornament	ornament
22816	445049	July 7, 2009, 4:36 pm	0	3	ornament	ornament
24570	956283	July 10, 2009, 7:09 am	0	2	ornament	ornament
22448	810458	July 5, 2009, 1:14 am	0	2	Oxygen tank	tank
75	919575	June 17, 2009, 7:27 am	0	4	perfume	perfume
5088	650078	June 19, 2009, 2:50 pm	0	3	perfume	perfume
10371	590208	June 22, 2009, 9:02 am	0	4	perfume	perfume
10529	776288	June 22, 2009, 9:16 am	0	3	perfume	perfume
11258	143059	June 22, 2009, 10:02 am	0	4	perfume	perfume
11560	5724	June 22, 2009, 10:23 am	0	1	perfume	perfume
14055	551142	June 22, 2009, 4:08 pm	0	5	perfume	perfume
20109	10321	June 27, 2009, 4:55 pm	0	4	perfume	perfume
20641	206071	June 30, 2009, 8:42 am	0	2	perfume	perfume
23932	363556	July 9, 2009, 2:32 pm	0	2	perfume	perfume
25051	624463	July 26, 2009, 9:01 pm	0	3	perfume	perfume
6413	158589	June 20, 2009, 3:33 pm	0	3	perfume bottle	bottle
10033	850998	June 22, 2009, 8:47 am	0	5	perfume bottle	bottle
16201	525468	June 23, 2009, 9:51 am	0	4	perfume bottle	bottle
20708	427779	June 30, 2009, 1:12 pm	0	4	perfume bottle	bottle
20846	238007	June 30, 2009, 9:11 pm	0	2		
20986	462613	July 2, 2009, 7:27 am	0	1	perfume bottle	bottle
21231	428496	July 2, 2009, 11:23 am	0	3	perfume bottle	bottle
22396	893871	July 5, 2009, 1:06 am	0	4	perfume bottles	bottle
16901	775144	June 23, 2009, 12:00 pm	0	1	pipe	pipe
5545	661688	June 20, 2009, 1:47 am	0	2	Pipe fitting	fit
22347	887136	July 5, 2009, 1:03 am	0	1	plug it	plug
7336	816531	June 21, 2009, 2:50 am	0	5	plunger	plunger
8808	801397	June 22, 2009, 8:20 am	0	1	plunger	plunger
11362	827981	June 22, 2009, 10:12 am	0	1	plunger	plunger
10695	377214	June 22, 2009, 9:35 am	0	2	pocket watch	pocketwatch
13817	966180	June 22, 2009, 2:40 pm	0	4	Pocket watch	pocketwatch
16291	940217	June 23, 2009, 10:12 am	0	4	Pocket Watch	pocketwatch
6464	515220	June 20, 2009, 5:08 pm	0	3	pocketwatch	pocketwatch
19152	829265	June 25, 2009, 10:27 am	0	4	pocketwatch	pocketwatch
20318	245819	June 27, 2009, 4:58 pm	0	2	pocketwatch	pocketwatch
20907	981130	July 1, 2009, 1:39 pm	0	1	pocketwatch	pocketwatch
320	499709	June 17, 2009, 9:55 am	0	2	pot	pot
16707	453873	June 23, 2009, 10:39 am	0	4	potable	potable
4352	995834	June 19, 2009, 10:34 am	0	1	Potion	potion
9477	895327	June 22, 2009, 8:30 am	0	2		

12095	316582	June 22, 2009, 10:57 am	0	3	potion	potion
17482	398295	June 23, 2009, 6:35 pm	0	3		
7524	403292	June 21, 2009, 4:11 am	0	4	primitive timepiece	timepiece
7523	403292	June 21, 2009, 4:11 am	0	4	propane tank	tank
3252	17093	June 18, 2009, 4:42 pm	0	2	propane tank	tank
22159	711409	July 5, 2009, 1:01 am	0	3	propane tank	tank
5549	661688	June 20, 2009, 1:47 am	0	2	Pull ring release	release
16495	485626	June 23, 2009, 10:38 am	0	4	race	race
188	378918	June 17, 2009, 8:00 am	0	4	Reaction	react
18131	838721	June 24, 2009, 10:59 am	0	5	reservoir	reservoir
875	822034	June 17, 2009, 6:07 pm	0	4	ring	ring
11360	827981	June 22, 2009, 10:12 am	0	1	ring	ring
11807	539209	June 22, 2009, 10:39 am	0	2	ring	ring
15679	107641	June 23, 2009, 1:42 am	0	3	Ring	ring
4353	995834	June 19, 2009, 10:34 am	0	1	Rum	rum
5204	90818	June 19, 2009, 4:37 pm	0	3	Satellite	satellite
13024	599198	June 22, 2009, 12:57 pm	0	4	school bell	bell
322	499709	June 17, 2009, 9:55 am	0	2	science	science
3927	137754	June 18, 2009, 9:32 pm	0	5	scientific beaker	beaker
4907	116348	June 19, 2009, 1:47 pm	0	1	shooter	shoot
16203	525468	June 23, 2009, 9:51 am	0	4	bomb	bomb
22952	493636	July 7, 2009, 4:41 pm	0	1	small chimney	chimney
15285	483998	June 23, 2009, 12:11 am	0	3	smooth	smooth
8151	462771	June 21, 2009, 6:03 pm	0	5	solidity	solid
4721	36028	June 19, 2009, 12:23 pm	0	1	spherical container cap	cap
971	460023	June 17, 2009, 8:30 pm	0	4	stopwatch	stopwatch
1049	88013	June 17, 2009, 9:41 pm	0	1	stopwatch	stopwatch
2445	174444	June 18, 2009, 12:33 pm	0	3	stopwatch	stopwatch
4100	496450	June 19, 2009, 12:02 am	0	3	stopwatch	stopwatch
4506	437893	June 19, 2009, 11:48 am	0	5	stopwatch	stopwatch
4821	13935	June 19, 2009, 12:27 pm	0	2	stopwatch	stopwatch
6036	150672	June 20, 2009, 11:42 am	0	3	stopwatch	stopwatch
9412	142072	June 22, 2009, 8:28 am	0	2	stopwatch	stopwatch
10255	57607	June 22, 2009, 9:00 am	0	2	stopwatch	stopwatch
10693	377214	June 22, 2009, 9:35 am	0	2	stopwatch	stopwatch
11054	357160	June 22, 2009, 9:57 am	0	5	stopwatch	stopwatch
12939	941187	June 22, 2009, 12:45 pm	0	4	stopwatch	stopwatch
13022	599198	June 22, 2009, 12:57 pm	0	4	stopwatch	stopwatch
16035	948403	June 23, 2009, 9:29 am	0	5	stopwatch	stopwatch
16202	525468	June 23, 2009, 9:51 am	0	4	stopwatch	stopwatch
17179	198714	June 23, 2009, 3:30 pm	0	1	stopwatch	stopwatch
17821	954875	June 23, 2009, 10:04 pm	0	1	stopwatch	stopwatch
21435	45606	July 3, 2009, 3:36 pm	0	1	stopwatch	stopwatch
23073	628909	July 8, 2009, 9:19 am	0	5	stopwatch	stopwatch
23131	810786	July 8, 2009, 5:17 pm	0	4	stopwatch	stopwatch
24311	198587	July 10, 2009, 12:10 am	0	2	stopwatch	stopwatch
495	521328	June 17, 2009, 11:57 am	0	1	stopwatch	stopwatch
2136	994279	June 18, 2009, 11:20 am	0	3	Stopwatch	stopwatch
2762	467572	June 18, 2009, 3:03 pm	0	4	stopwatch	stopwatch
2888	117739	June 18, 2009, 3:28 pm	0	3	stopwatch	stopwatch
5353	798509	June 19, 2009, 7:23 pm	0	5	stopwatch	stopwatch
5832	645058	June 20, 2009, 4:42 am	0	1	stopwatch	stopwatch
6257	50	June 20, 2009, 3:33 pm	0	5	stopwatch	stopwatch
6463	515220	June 20, 2009, 5:08 pm	0	3	stopwatch	stopwatch
8081	506435	June 21, 2009, 5:31 pm	0	1	stopwatch	stopwatch
8877	868856	June 22, 2009, 8:21 am	0	1	stopwatch	stopwatch
9170	886942	June 22, 2009, 8:24 am	0	5	stopwatch	stopwatch
9316	732822	June 22, 2009, 8:26 am	0	2	stopwatch	stopwatch
9742	263882	June 22, 2009, 8:40 am	0	3	stopwatch	stopwatch
9942	430318	June 22, 2009, 8:46 am	0	4	stopwatch	stopwatch
10788	536984	June 22, 2009, 9:53 am	0	5	stopwatch	stopwatch
11967	477050	June 22, 2009, 10:46 am	0	1	stopwatch	stopwatch
12416	197717	June 22, 2009, 11:29 am	0	5	stopwatch	stopwatch
12825	534094	June 22, 2009, 12:20 pm	0	3	stopwatch	stopwatch
13677	501612	June 22, 2009, 2:21 pm	0	3	Stopwatch	stopwatch
14177	771126	June 22, 2009, 4:50 pm	0	5	stopwatch	stopwatch

14754	996534	June 22, 2009, 6:53 pm	0	2	stopwatch	stopwatch
14936	596598	June 22, 2009, 8:23 pm	0	1	stopwatch	stopwatch
15079	854979	June 22, 2009, 9:28 pm	0	5	Stopwatch	stopwatch
15680	107641	June 23, 2009, 1:42 am	0	3	StopWatch	stopwatch
16094	816	June 23, 2009, 9:29 am	0	1	stopwatch	stopwatch
16493	485626	June 23, 2009, 10:38 am	0	4	stopwatch	stopwatch
19151	829265	June 25, 2009, 10:27 am	0	4	stopwatch	stopwatch
19619	400177	June 25, 2009, 5:53 pm	0	5	stopwatch	stopwatch
19759	908128	June 25, 2009, 9:08 pm	0	3	stopwatch	stopwatch
20022	911628	June 26, 2009, 3:26 pm	0	2	stopwatch	stopwatch
20110	10321	June 27, 2009, 4:55 pm	0	4	stopwatch	stopwatch
21093	168047	July 2, 2009, 9:58 am	0	2	stopwatch	stopwatch
21525	60081	July 3, 2009, 9:20 pm	0	2	stopwatch	stopwatch
22612	98966	July 5, 2009, 1:16 am	0	4	Stopwatch	stopwatch
7931	360187	June 21, 2009, 9:48 am	0	4	storage	storage
21526	60081	July 3, 2009, 9:20 pm	0	2	storage container	container
1151	877704	June 17, 2009, 11:18 pm	0	5	tank	tank
3251	17093	June 18, 2009, 4:42 pm	0	2	tank	tank
22055	780335	July 5, 2009, 1:01 am	0	2	tank	tank
25052	624463	July 26, 2009, 9:01 pm	0	3	tank	tank
22158	711409	July 5, 2009, 1:01 am	0	3	telescope	telescope
10696	377214	June 22, 2009, 9:35 am	0	2	telescope station	station
2702	554371	June 18, 2009, 2:43 pm	0	1		
6259	50	June 20, 2009, 3:33 pm	0	5	time	time
8150	462771	June 21, 2009, 6:03 pm	0	5	time	time
8878	868856	June 22, 2009, 8:21 am	0	1	time	time
9221	102122	June 22, 2009, 8:25 am	0	1	Time	time
12597	422273	June 22, 2009, 11:53 am	0	5		
16494	485626	June 23, 2009, 10:38 am	0	4	time	time
21094	168047	July 2, 2009, 9:58 am	0	2	time	time
21434	45606	July 3, 2009, 3:36 pm	0	1	time	time
23983	882068	July 9, 2009, 4:53 pm	0	4	time	time
24312	198587	July 10, 2009, 12:10 am	0	2	time	time
24627	993161	July 10, 2009, 8:12 am	0	2	time	time
6832	315455	June 21, 2009, 12:18 am	0	4	time bomb	bomb
6883	755984	June 21, 2009, 1:19 am	0	2	time bomb	bomb
18130	838721	June 24, 2009, 10:59 am	0	5	time bomb	bomb
4099	496450	June 19, 2009, 12:02 am	0	3	time not set	time
3361	473062	June 18, 2009, 4:49 pm	0	5	time remaining	time
8879	868856	June 22, 2009, 8:21 am	0	1	timed	time
10175	514528	June 22, 2009, 8:54 am	0	2	timed	time
16840	124484	June 23, 2009, 11:44 am	0	1	timed	time
24676	706477	July 10, 2009, 4:57 pm	0	5	timed	time
8880	868856	June 22, 2009, 8:21 am	0	1	timed event	event
2446	174444	June 18, 2009, 12:33 pm	0	3	timer	timer
4098	496450	June 19, 2009, 12:02 am	0	3	timer	timer
5354	798509	June 19, 2009, 7:23 pm	0	5	timer	timer
6037	150672	June 20, 2009, 11:42 am	0	3	timer	timer
10174	514528	June 22, 2009, 8:54 am	0	2	Timer	timer
11966	477050	June 22, 2009, 10:46 am	0	1	timer	timer
12739	402008	June 22, 2009, 12:09 pm	0	5	timer	timer
14178	771126	June 22, 2009, 4:50 pm	0	5	timer	timer
14408	790997	June 22, 2009, 5:21 pm	0	4	Timer	timer
15282	483998	June 23, 2009, 12:11 am	0	3	timer	timer
17181	198714	June 23, 2009, 3:30 pm	0	1	timer	timer
19239	286011	June 25, 2009, 11:08 am	0	1	timer	timer
19618	400177	June 25, 2009, 5:53 pm	0	5	timer	timer
23212	123092	July 8, 2009, 5:33 pm	0	3	timer	timer
24729	217809	July 10, 2009, 10:59 pm	0	2	timer	timer
22613	98966	July 5, 2009, 1:16 am	0	4	Timpiece	timepiece
8338	756452	June 21, 2009, 10:30 pm	0	4	toilet	toilet
21977	325073	July 5, 2009, 12:59 am	0	3	toilet	toilet
22616	98966	July 5, 2009, 1:16 am	0	4	Toilet	toilet
11723	185973	June 22, 2009, 10:35 am	0	4	toilet cover	cover
7834	445674	June 21, 2009, 8:46 am	0	1	toilet top down	toilet
5550	661688	June 20, 2009, 1:47 am	0	2	Towel holder	holder

23392	522801	July 8, 2009, 6:17 pm	0	2	modern jar	jar
21649	571808	July 5, 2009, 12:51 am	0	3	unknown	unknown
3608	37503	June 18, 2009, 6:55 pm	0	3	useless stopwatch	stopwatch
9740	263882	June 22, 2009, 8:40 am	0	3	vessel	vessel
14529	755795	June 22, 2009, 5:58 pm	0	4	vial	vial
25050	624463	July 26, 2009, 9:01 pm	0	3	vial	vial
3682	894721	June 18, 2009, 7:15 pm	0	1	video games	game
1153	877704	June 17, 2009, 11:18 pm	0	5	vile	vial
3683	894721	June 18, 2009, 7:15 pm	0	1	vile	vial
2376	493789	June 18, 2009, 11:54 am	0	1	watch	watch
6258	50	June 20, 2009, 3:33 pm	0	5	watch	watch
9315	732822	June 22, 2009, 8:26 am	0	2	watch	watch
10694	377214	June 22, 2009, 9:35 am	0	2	watch	watch
11902	474084	June 22, 2009, 10:45 am	0	5	watch	watch
17668	272460	June 23, 2009, 9:23 pm	0	1	watch	watch
18129	838721	June 24, 2009, 10:59 am	0	5	watch	watch
20796	552874	June 30, 2009, 3:11 pm	0	1	watch	watch
7474	459888	June 21, 2009, 3:32 am	0	5	watch symbol engineering tank symbol	watch
7474	459888	June 21, 2009, 3:32 am	0	5	watch symbol engineering tank symbol	tank
1373	89401	June 18, 2009, 1:28 am	0	3	Water	water
10461	276925	June 22, 2009, 9:11 am	0	5	water	water
13298	389751	June 22, 2009, 1:45 pm	0	3	water	water
16705	453873	June 23, 2009, 10:39 am	0	4	water	water
9658	391108	June 22, 2009, 8:36 am	0	5	water ballon	balloon
16414	790291	June 23, 2009, 10:27 am	0	3	water ballon	balloon
18395	715165	June 24, 2009, 2:20 pm	0	2	water balloon	balloon
19052	730845	June 25, 2009, 9:08 am	0	3	water baloon	balloon
2266	729346	June 18, 2009, 11:45 am	0	3	water bottle	bottle
14310	436038	June 22, 2009, 4:50 pm	0	4	water canister	canister
22447	810458	July 5, 2009, 1:14 am	0	2	Water tank	tank
7162	343379	June 21, 2009, 2:22 am	0	3	waterballon	water balloon
7164	343379	June 21, 2009, 2:22 am	0	3	wearing tiny hat	hat
21331	260833	July 3, 2009, 1:00 am	0	4		
24520	766632	July 10, 2009, 6:52 am	0	4	xmas ornament	ornament
12276	285183	June 22, 2009, 11:27 am	0	5	yellow	yellow
1	409888	June 16, 2009, 6:17 pm	0	3		
7064	483232	June 21, 2009, 1:30 am	0	4		

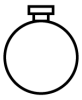
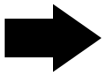
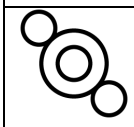
Table 16 – Response Data (for Icon #00)

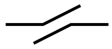
The data above shows the demographic information for the first 10 participants. "uID" represents the unique number which increases by 1 when a new participant is added. "partID" is the participant ID which is used to match the participant's responses to the demographic information in another database. These numbers will match. The "date" column denotes when the data was submitted. The "num" column shows the icon number (in this case, #00). "color" represents the numerical value of the icon's color. The "initData" column is the original data for the response, and "newData" is the response after revision.

Appendix D – Graphs and Data Analysis

LSA Results

The chart below lists all icons and the first 10 LSA output terms generated from the input of all responses for the noted color from the respective icon. The algorithm is the nearest neighbors with first-year general college corpus. Next to each output term is the respective cosine.

Icon	ALL	Color 1: BLACK	Color 2: RED	Color 3: BLUE	Color 4: GREEN	Color 5: ORANGE
	.38, gushes	.38, bulbs	.47, bulbs	.46, water	.40, reaction	.40, clock
	.38, bubbles	.36, christmas	.45, bulb	.46, tank	.39, syntheses	.36, o
	.38, tank	.36, rockefller	.41, lights	.42, glass	.38, reactions	.34, flash
	.37, bottle	.36, luau	.40, flashlight	.40, nonvented	.37, flask	.33, bulb
	.35, jar	.36, altadena	.36, lamp	.39, bubbles	.36, reactant	.33, water
	.35, lit	.35, lit	.35, tank	.39, gushes	.36, bottle	.32, watch
	.34, bulb	.34, lighted	.35, plugged	.38, jar	.36, reactants	.32, bubbles
	.33, bulbs	.34, light	.34, jar	.38, bottle	.35, explosion	.32, lights
	.33, ignite	.34, lights	.34, switches	.37, soapy	.35, mno4	.32, bulbs
	.32, jars	.34, flash	.34, light	.36, ignited	.35, experimently	.31, hostel
	.56, direction	.61, right	.63, right	.64, right	.64, right	.65, right
	.54, right	.58, direction	.48, left	.50, direction	.48, left	.56, direction
	.43, left	.50, left	.47, direction	.47, left	.41, go	.51, left
	.41, directions	.44, directions	.46, go	.41, go	.39, side	.42, unset
	.40, opposite	.42, unset	.41, arrow	.40, kingpin	.39, unset	.42, ulnar
	.39, arrow	.40, pointing	.37, directions	.38, arrow	.39, turn	.42, supination
	.38, pointing	.39, arrow	.37, unset	.37, unset	.38, kingpin	.42, pronation
	.38, smoothest	.38, clockwise	.35, overtaking	.37, directions	.38, cornering	.42, plantar
	.36, ulnar	.38, kingpin	.35, kingpin	.37, cornering	.38, ulnar	.42, adduction
	.36, supination	.38, ribboned	.35, ribboned	.36, turn	.38, supination	.42, eversion
	.48, waves	.51, center	.49, presbyopia	.56, waves	.40, pivoted	.42, circle
	.45, antenna	.50, eye	.47, eye	.52, crests	.39, wheel	.38, center
	.44, transverse	.46, cornea	.46, waves	.52, unpolarized	.39, green	.37, l2
	.43, unpolarized	.46, eyeball	.46, antenna	.50, crest	.36, spokes	.35, circles
	.43, wave	.45, retina	.42, optical	.50, wave	.34, torque	.35, vertices
	.42, crests	.43, sclera	.41, retina	.50, troughs	.33, rotating	.35, l6
	.42, troughs	.40, iris	.41,farsightedness	.49, transverse	.32, center	.35, l5
	.41, megahertz	.39, 715th	.41, jodrell	.48, trough	.32, litmus	.34, antinodal
	.41, crest	.38, astigmatism	.40, arecibo	.46, ripples	.32, turn	.33, light
	.40, center	.37, ball	.40, nonsteerable	.46, wavelength	.32, semicircular	.33, hole
	.59, orbits	.57, orbiting	.54, orbits	.72, planets	.45, orbiting	.62, atoms
	.58, orbiting	.57, planets	.52, planets	.71, moons	.45, orbits	.57, atom
	.57, planets	.56, moons	.52, orbiting	.71, asteroids	.44, jupiter	.56, molecule
	.56, moons	.55, asteroids	.51, circling	.70, jupiter	.44, moons	.53, valence
	.56, jupiter	.53, planet	.48, moons	.69, miniplanets	.44, revolutionibus	.52, bonding
	.56, planetary	.53, miniplanets	.47, revolve	.69, planet	.44, maestlin	.52, diatomic
	.56, planet	.53, jupiter	.47, planetary	.68, orbits	.44, uranus	.52, covalently
	.54, mars	.53, orbits	.47, planet	.67, revolve	.43, planet	.52, pcl5
	.54, revolve	.53, orbit	.46, orbit	.67, pulsars	.43, mars	.52, elecrons
	.53, asteroids	.53, revolve	.46, jupiter	.67, novas	.43, planetary	.52, covalent

	.48, hole	.56, hole	.54, hole	.49, hole	.56, hole	.60, hole
	.38, touchup	.40, trapdoor	.37, touchup	.40, here	.41, holes	.39, holes
	.38, magnotta	.39, go	.37, magnotta	.38, touchup	.39, here	.35, into
	.36, opening	.39, here	.37, trapdoor	.38, magnotta	.39, where	.35, touchup
	.35, into	.38, goes	.36, holes	.37, place	.38, countersink	.35, magnotta
	.35, trapdoor	.36, inside	.35, pile	.36, opening	.35, trapdoor	.35, dig
	.34, out	.36, holes	.34, out	.35, spot	.34, pile	.35, place
	.34, chute	.36, opening	.34, into	.34, trapdoor	.34, go	.34, put
	.34, then	.35, tunnel	.34, kneebends	.34, where	.34, into	.34, out
	.34, push	.34, through	.33, opening	.33, fall	.33, awl	.34, go
	.42, sign	.55, stop	.53, stop	.44, stop	.43, table	.64, stop
	.39, red	.51, sign	.46, sign	.41, sign	.41, poules	.55, sign
	.38, stop	.44, signs	.44, poules	.39, brakes	.41, napolitain	.44, signs
	.38, tables	.38, midblock	.44, napolitain	.38, flashers	.41, absinthe	.42, intersections
	.38, sarkany	.38, jaywalkers	.44, absinthe	.37, drivers	.41, dites	.41, pedestrian
	.38, recrowned	.38, jaywalker	.44, dites	.36, poules	.39, green	.40, pavement
	.38, apoplectic	.38, crosswalks	.42, red	.36, napolitain	.38, tables	.39, stopped
	.38, mordantly	.37, poules	.41, midblock	.36, absinthe	.38, stop	.39, street
	.38, table	.37, napolitain	.41, jaywalkers	.36, dites	.38, sign	.39, curb
	.38, poules	.37, absinthe	.41, jaywalker	.36, midblock	.37, pernod	.38, flashers
	.56, highway	.53, road	.56, circuit	.60, road	.63, road	.54, road
	.55, road	.46, path	.55, switch	.57, highway	.57, highway	.51, path
	.49, path	.44, lane	.54, circuits	.51, along	.50, path	.51, circuit
	.48, lane	.43, highway	.53, resistors	.48, path	.48, lane	.50, switch
	.46, roadway	.42, gate	.52, connect	.47, lane	.45, roads	.50, r1
	.45, connect	.41, parallel	.51, amp	.47, roads	.43, udine	.49, highway
	.44, roads	.40, hightown	.51, path	.45, roadbed	.43, hightown	.49, circuits
	.44, intersections	.40, coopersville	.49, r1	.45, intersections	.43, coopersville	.49, connect
	.43, obstructions	.40, bluerock	.49, fuses	.45, roadway	.43, bluerock	.46, resistors
	.43, circuit	.38, r1	.49, wiring	.44, packhorse	.43, aymo	.45, fuses
	.76, bulb	.77, bulbs	.77, bulbs	.78, bulbs	.77, bulbs	.80, bulbs
	.75, bulbs	.77, bulb	.77, bulb	.77, bulb	.77, bulb	.80, bulb
	.70, 6100	.73, light	.72, light	.73, light	.70, light	.75, light
	.66, chemcials	.70, 6100	.71, 6100	.70, invenion	.66, 6100	.71, flashlight
	.65, light	.68, flashlight	.69, flashlight	.69, flashlight	.65, flashlight	.69, invenion
	.64, lamp	.65, invenion	.66, invenion	.68, 6100	.65, invenion	.69, 6100
	.64, flashlight	.62, chemcials	.65, chemcials	.65, lamp	.64, lamp	.68, lamp
	.63, invenion	.62, incandescent	.62, lights	.61, incandescent	.62, chemcials	.65, chemcials
	.62, toaster	.61, lamp	.62, flashlights	.60, chemcials	.61, incandescent	.64, incandescent
	.61, incandescent	.58, toaster	.62, lamp	.58, lights	.59, toaster	.62, lights
	.51, windows	.44, windows	.45, window	.50, window	.49, window	.53, windows
	.44, corner	.40, window	.44, box	.43, windows	.45, street	.52, window
	.44, window	.39, doors	.44, boxes	.37, boulevard	.45, corner	.49, corner
	.40, doors	.37, corner	.39, red	.34, street	.44, windows	.43, doors
	.39, street	.37, flag	.38, bertday	.34, corner	.42, red	.42, spire
	.38, corners	.35, map	.38, meeow	.34, frame	.40, box	.42, street
	.37, red	.34, maps	.38, corners	.34, flag	.39, boxes	.37, church
	.37, spatially	.34, square	.36, moldings	.34, sarkany	.36, caps	.36, square
	.37, chandeliered	.34, rooms	.35, windows	.34, recrowned	.35, meecham	.36, bellingham
	.37, spire	.34, ceiling	.35, rectangular	.34, apoplectic	.35, juliana	.35, pavement
	.62, steering	.66, steering	.66, wheel	.65, steering	.68, wheel	.60, wheel
	.59, brakes	.66, wheels	.63, wheels	.60, wheel	.66, wheels	.59, wheels
	.57, wheels	.65, wheel	.61, steering	.59, brakes	.61, pedals	.57, pedals
	.55, brake	.64, brakes	.58, pedals	.58, wheels	.59, steering	.56, steering
	.54, rear	.58, brake	.54, brakes	.55, brake	.57, brakes	.53, bicycle
	.54, wheel	.57, rear	.53, starley	.51, rear	.55, starley	.52, brakes
	.50, flashers	.55, tires	.53, highwheeler	.49, wipers	.55, highwheeler	.52, starley
	.49, tires	.55, pedals	.52, pedal	.48, lindy	.55, handlebars	.52, highwheeler
	.48, wipers	.53, pedal	.51, handlebars	.48, planetaries	.54, pedal	.48, pedal
	.47, pedals	.52, planetaries	.51, bicycle	.47, pedals	.54, rear	.48, handlebars

	.53, drawers	.48, train	.55, filing	.44, shelves	.45, drawers	.48, door
	.48, file	.46, railroad	.54, file	.44, library	.45, files	.46, stairs
	.48, files	.42, drawers	.53, filed	.43, drawers	.44, file	.46, opened
	.48, cabinets	.40, freight	.52, alphabetic	.43, librarian	.43, railroad	.45, doors
	.46, tickler	.40, files	.52, folders	.41, books	.43, cabinets	.41, stairway
	.44, vocalist	.40, file	.52, caption	.39, alphabetically	.42, microfilm	.39, windows
	.44, alphabetic	.40, cabinets	.51, tickler	.39, caras	.42, film	.38, railroad
	.44, filed	.39, printouts	.51, folder	.38, tickler	.42, lading	.38, drawers
	.42, caption	.39, microfilm	.51, guides	.38, cabinets	.42, vocalist	.37, storeroom
	.42, tabs	.39, tracks	.50, indexing	.37, vocalist	.42, train	.37, shelves
	.60, jewish	.60, star	.63, jewish	.60, jewish	.61, star	.67, star
	.59, jews	.57, jews	.62, jews	.60, jews	.59, stars	.65, stars
	.58, judaism	.57, jewish	.61, jerusalem	.59, judaism	.59, alguhl	.62, alguhl
	.58, hebrew	.57, stars	.60, hebrew	.59, hebrew	.57, algol	.60, algol
	.58, jerusalem	.56, judaism	.60, palestine	.58, jerusalem	.56, dipper	.58, jewish
	.55, faiths	.55, hebrew	.59, judaism	.57, jew	.56, lyra	.57, jews
	.55, palestine	.54, jew	.58, jew	.56, palestine	.56, constellation	.57, brightest
	.55, jew	.54, jerusalem	.58, zionists	.56, prophets	.55, cygnus	.57, constellation
	.54, prophets	.54, alguhl	.58, zionist	.55, zionists	.54, scorpius	.56, lyra
	.54, zionists	.54, centauri	.57, prophets	.55, messiah	.54, sagittarius	.56, constellations
	.68, sun	.78, sun	.75, sun	.75, sun	.79, sun	.77, sun
	.60, shines	.59, shines	.57, shines	.62, shines	.63, shines	.60, shines
	.54, sunlight	.56, light	.50, glare	.57, light	.57, sunlight	.52, warms
	.52, glow	.55, billionth	.48, billionth	.56, sunlight	.54, solar	.52, telkes
	.50, shine	.52, shine	.47, telkes	.53, shine	.49, billionth	.52, solar
	.50, light	.52, corona	.47, solar	.52, firefly	.48, telkes	.49, millon
	.49, bright	.52, sunlight	.46, glow	.52, shining	.48, shining	.48, sunny
	.48, insolation	.52, glare	.45, millon	.52, luminous	.47, millon	.48, sunshine
	.48, shining	.51, rays	.45, warms	.51, glow	.47, pictogram	.47, billionth
	.47, firefly	.51, helios	.45, prominences	.51, glare	.46, shine	.46, shining
	.82, moon	.93, moon	.87, moon	.90, moon	.90, moon	.90, moon
	.75, gibbous	.84, lunar	.79, lunar	.83, gibbous	.82, gibbous	.82, gibbous
	.75, eclipse	.84, gibbous	.79, gibbous	.80, lunar	.82, eclipse	.81, lunar
	.71, lunar	.81, eclipse	.78, eclipse	.80, eclipse	.79, lunar	.79, eclipse
	.71, earthlight	.79, earthlight	.73, earthshine	.77, earthshine	.77, earthlight	.77, earthlight
	.70, waxing	.78, earthshine	.73, earthlight	.76, earthlight	.76, earthshine	.76, earthshine
	.70, earthshine	.76, waxing	.72, lem	.76, waxing	.75, waxing	.75, waxing
	.64, umbra	.75, lem	.71, waxing	.72, lem	.71, lem	.72, lem
	.64, lem	.72, borman	.68, anorthosite	.69, anorthosite	.71, daysabout	.70, anorthosite
	.64, atomsphere	.72, anorthosite	.67, daysabout	.69, daysabout	.69, umbra	.69, perigee
	.57, snow	.60, snow	.62, snow	.70, snow	.44, snow	.57, snow
	.49, snowflakes	.54, man	.51, snowflakes	.61, winter	.42, snowflakes	.54, snowflakes
	.48, drifts	.52, snowman	.50, drifts	.56, blizzard	.41, larger	.53, ice
	.46, blizzard	.51, drifts	.49, snowman	.56, snowman	.38, drifts	.49, snowfall
	.45, snowfall	.51, snowflakes	.48, man	.56, snowstorm	.38, snowflake	.49, drifts
	.43, snowstorm	.48, jizo	.47, snowfall	.55, cold	.37, freighted	.46, snowfields
	.42, snowball	.46, snowfall	.45, snowstorm	.54, drifts	.37, capsizing	.46, hailstone
	.42, snowman	.45, whiplashes	.44, whiplashes	.51, respoke	.37, moosewood	.45, snowball
	.42, frozen	.44, snowstorm	.44, blizzard	.50, snowfall	.37, lumberjack	.44, tiktaliktak
	.41, freeze	.44, blizzard	.43, pinu	.49, snowflakes	.37, man	.44, blizzard
	.73, ice	.83, ice	.83, ice	.85, ice	.84, ice	.82, ice
	.69, cream	.79, cream	.77, cream	.78, cream	.77, cream	.77, cream
	.59,semicentennial	.68,semicentennial	.66, glacier	.69,semicentennial	.68, glacier	.67,semicentennial
	.59, pretenders	.68, pretenders	.66, glaciers	.69, pretenders	.68, glaciers	.67, pretenders
	.59,concessionaire	.68,concessionaire	.65,semicentennial	.69,concessionaire	.66,semicentennial	.67,concessionaire
	.57, glaciers	.66, glaciers	.65, pretenders	.67, glaciers	.66, pretenders	.65, glacier
	.57, glacier	.66, glacier	.65,concessionaire	.67, glacier	.66,concessionaire	.65, glaciers
	.55, frozen	.62, glacial	.62, refreezes	.63, refreezes	.64, refreezes	.61, refreezes
	.54, vanilla	.61, vanilla	.62, glacial	.63, glacial	.63, glacial	.60, vanilla
	.53, refreezes	.61, refreezes	.61, frozen	.61, floe	.61, neve	.60, glacial

	.37, orange	.39, jab	.45, cut	.39, taffy	.40, orange	.43, cream
	.37, boiled	.37, hole	.39, piece	.33, bird	.40, green	.38, vanilla
	.37, taffy	.34, blunt	.38, knife	.32, doves	.38, jellylike	.37, slices
	.36, piece	.34, holes	.36, cutting	.32, vase	.36, boiled	.37, ooky
	.35, hole	.33, pin	.34, cardboard	.32, beak	.36, frog	.36, scoops
	.34, unslipped	.32, tapered	.33, plastice	.32, birtd	.35, greens	.35, piece
	.34, sikyatki	.32, lp	.33, brads	.31, quiver	.33, tadpole	.35, cubes
	.34, rumps	.32, mallet	.33, peel	.31, object	.33, jelly	.35, dime
	.34, hano	.32, muffling	.32, taffy	.31, flier	.33, ooky	.34, pie
	.34, slice	.32, threaded	.31, puppeteer	.31, hmm	.32, slices	.34, unpeeled
	.61, drink	.62, coffee	.80, coffee	.70, drink	.65, coffee	.71, coffee
	.60, drank	.60, cup	.74, cup	.67, drank	.59, drank	.63, cup
	.60, coffee	.58, drank	.68, drank	.66, coffee	.58, cup	.61, drank
	.60, beer	.56, wine	.61, drink	.64, cup	.58, beer	.59, beer
	.58, wine	.55, drink	.59, sip	.63, wine	.58, drink	.59, wine
	.57, cup	.55, sip	.58, toast	.62, beer	.55, wine	.58, drink
	.57, vodka	.54, beer	.57, sipped	.62, sip	.54, drinks	.56, sip
	.56, drinks	.52, drinks	.57, wine	.62, vodka	.54, vodka	.56, vodka
	.56, beverage	.52, vodka	.55, vodka	.61, drinks	.53, beverage	.55, sipped
	.56, sip	.51, whiskey	.55, beer	.60, whiske	.52, whiskey	.54, whiskey
	.52, bag	.52, bag	.56, bag	.54, bag	.58, bag	.49, grocery
	.45, grocery	.46, purse	.46, dogfood	.40, purse	.49, bags	.46, bag
	.44, bags	.44, bags	.46, catsups	.38, bags	.42, shop	.45, store
	.43, boxes	.40, weight	.44, bags	.38, pocket	.41, purse	.44, cream
	.42, shop	.40, suitcase	.42, boxes	.36, suitcase	.41, suitcase	.43, shopping
	.41, dogfood	.37, shopping	.41, box	.34, meecham	.37, gloves	.42, bags
	.41, catsups	.36, weigh	.39, purse	.34, juliana	.36, shopping	.41, decice
	.41, purse	.35, buoyant	.36, lid	.34, warehouse	.35, grocery	.40, ebik
	.40, shopping	.34, buoyancy	.36, red	.34, boxes	.35, package	.40, edie
	.39, pocket	.34, pocket	.36, butcher	.33, shop	.35, spats	.40, shoppers
	.43, bag	.48, bag	.47, bag	.43, bag	.39, pocket	.57, bag
	.42, button	.39, lid	.41, pocket	.37, put	.35, green	.45, bags
	.41, unpainted	.39, button	.38, 5	.35, pocket	.34, bag	.45, boxes
	.40, boxes	.38, box	.38, basket	.34, corner	.34, unpainted	.45, opened
	.39, fumbled	.37, opened	.35, 3	.34, gloves	.33, bellboy	.43, lock
	.39, pocket	.37, basket	.35, picked	.34, purse	.33, purse	.43, box
	.38, opened	.37, boxes	.34, 4	.34, fumbled	.31, button	.41, purse
	.38, box	.35, bags	.34, holding	.34, down	.31, shoulder	.41, stairs
	.37, popped	.34, unpainted	.33, dogfood	.34, suitcase	.31, computer	.41, door
	.37, buttons	.34, paperweights	.33, catsups	.34, hat	.31, fumbled	.40, suitcase
	.67, star	.88, star	.80, star	.80, star	.83, star	.72, star
	.64, brightest	.84, stars	.74, brightest	.74, stars	.77, stars	.67, stars
	.63, rigel	.77, algol	.74, stars	.72, rigel	.74, cygnus	.65, dipper
	.63, cygnus	.77, brightest	.72, cygnus	.72, cygnus	.73, brightest	.64, constellation
	.62, betelgeuse	.77, alguhl	.71, rigel	.71, dipper	.72, constellation	.63, brightest
	.62, stars	.77, dipper	.71, scorpius	.71, brightest	.72, dipper	.63, cygnus
	.61, dipper	.76, constellation	.71, sagittarius	.70, constellation	.72, rigel	.61, erin
	.60, scorpius	.75, cygnus	.71, asterism	.69, betelgeuse	.71, constellations	.61, constellations
	.60, sagittarius	.74, constellations	.70, lyra	.68, lyra	.70, cassiopeia	.60, rigel
	.60, asterism	.73, rigel	.69, dipper	.67, supergiants	.69, betelgeuse	.60, cassiopeia
	.45, yellow	.52, black	.57, stop	.37, blue	.56, green	.39, stop
	.41, green	.44, stop	.52, sign	.37, sign	.43, ball	.38, intersections
	.41, blue	.37, sign	.44, signs	.36, ovals	.39, sign	.35, sign
	.38, orange	.35, du	.42, intersections	.36, shape	.39, stop	.34, pedestrian
	.36, red	.35, street	.40, pedestrian	.35, blocks	.38, salvadoreans	.34, organelle
	.36, unslipped	.35, matinees	.38, streetful	.34, moneran	.38, salvadorean	.33, traffic
	.36, sikyatki	.34, husbandless	.38, guideposts	.33, block	.38, misplaying	.32, drivers
	.36, rumps	.34, blacks	.37, midblock	.31, cell	.37, mitt	.32, pedestrians
	.36, hano	.33, walham	.37, jaywalkers	.31, stop	.37, dribbling	.32, midblock
	.35, sign	.33, sreading	.37, jaywalker	.31, limburger	.37, pitcher	.32, jaywalkers

	.56, write	.57, pencil	.75, write	.71, write	.62, pencil	.69, write
	.56, pencil	.55, write	.74, writing	.66, writing	.61, write	.65, writing
	.53, writing	.53, pencils	.67, revising	.57, pencil	.58, writing	.58, pencil
	.52, draw	.51, draw	.64, prewriting	.57, revising	.56, draw	.57, nonstop
	.51, pencils	.50, calligraphic	.64, nonstop	.56, rewrite	.55, pencils	.57, revising
	.49, jotting	.48, writing	.63, teri	.54, prewriting	.51, stylus	.56, jotting
	.46, stylus	.47, rewrite	.62, freewriting	.54, nonstop	.50, revising	.55, freewriting
	.46, rewrite	.46, brushwork	.59, draft	.54, teri	.49, rewrite	.54, prewriting
	.45, revising	.45, lettering	.59, rewrite	.52, draw	.48, jotting	.53, pencils
	.45, calligraphic	.43, stylus	.57, academicians	.52, draft	.48, teri	.53, rewrite
	.60, write	.74, write	.60, write	.67, write	.67, write	.69, write
	.57, writing	.73, writing	.59, writing	.63, writing	.64, writing	.64, pencil
	.57, pencil	.66, revising	.57, pencil	.57, nonstop	.61, nonstop	.58, writing
	.53, revising	.62, nonstop	.56, revising	.56, revising	.60, pencil	.55, pencils
	.51, nonstop	.62, prewriting	.53, nonstop	.54, rewrite	.59, revising	.55, rewrite
	.49, prewriting	.60, rewrite	.52, prewriting	.53, prewriting	.58, freewriting	.53, draw
	.49, rewrite	.60, teri	.51, rewrite	.53, pencil	.55, prewriting	.52, pen
	.48, jotting	.58, freewriting	.50, jotting	.52, freewriting	.54, rewrite	.52, revising
	.47, teri	.57, draft	.50, draft	.52, teri	.54, teri	.51, teri
	.47, pen	.56, proofreading	.50, teri	.49, pen	.53, jotting	.50, nonstop
	.54, write	.57, pencil	.53, write	.63, write	.65, write	.63, write
	.51, writing	.56, write	.51, red	.60, writing	.60, writing	.61, writing
	.51, pencil	.54, writing	.50, writing	.52, revising	.54, revising	.56, nonstop
	.46, pen	.52, pen	.50, pen	.52, pencil	.54, nonstop	.56, pencil
	.44, freewriting	.47, revising	.50, pencil	.51, prewriting	.53, freewriting	.55, revising
	.43, red	.46, freewriting	.43, jotting	.51, nonstop	.53, pencil	.54, freewriting
	.43, outlines	.45, rewrite	.43, freewriting	.49, rewrite	.53, pen	.53, prewriting
	.43, revising	.45, prewriting	.43, revising	.48, freewriting	.52, rewrite	.52, rewrite
	.43, stylus	.44, jotting	.43, graphology	.46, teri	.51, prewriting	.51, teri
	.43, nonstop	.44, nonstop	.43, graphologists	.46, pen	.50, teri	.50, draft
	.48, 5x	.44, tree	.46, tree	.64, magnifying	.56, tree	.53, 5x
	.48, 10x	.38, person	.40, trunk	.63, lenses	.48, trunk	.53, 10x
	.45, magnifying	.37, pettishly	.37, squirrel	.62, lens	.42, limb	.50, magnifying
	.44, magnifies	.36, trunk	.37, chirr	.62, magnify	.41, squirrel	.49, magnify
	.44, convex	.36, limb	.36, person	.61, convex	.41, 5x	.48, lenses
	.43, magnify	.35, squirrel	.36, cherry	.61, eyepiece	.41, 10x	.48, magnifies
	.43, lenses	.34, mouton	.34, male	.61, 5x	.39, pettishly	.47, magnification
	.43, concave	.34, chirr	.34, female	.61, 10x	.39, chirr	.47, lens
	.43, lens	.33, bedjacket	.33, limb	.60, magnification	.38, cherry	.46, eyepiece
	.43, eyepiece	.32, pruned	.33, oak	.60, magnifies	.38, tomoe	.46, convex
	.52, halves	.49, half	.40, court	.54, gibbous	.41, halves	.55, divides
	.42, half	.48, halves	.38, supreme	.52, half	.40, half	.55, halves
	.41, circle	.42, hemispheres	.38, taper	.52, moon	.37, circle	.53, half
	.39, divide	.38, divide	.37, bevel	.50, earthshine	.35, screw	.51, divide
	.37, divides	.36, callosum	.37, screw	.50, eclipse	.33, chamfer	.48, spindle
	.35, handoffs	.36, brain	.37, justices	.49, waxing	.33, taper	.46, division
	.35, hemispheres	.35, sperry	.37, abrams	.48, semicircle	.32, handoffs	.42, mitosis
	.34, semicircle	.35, torsten	.37, dissented	.47, lunar	.31, green	.42, micronucleus
	.33, spindle	.35, neurology	.37, dagenhart	.46, umbra	.31, circumference	.42, macronucleus
	.33, screw	.35, epileptics	.37, appellate	.46, circle	.31, bevel	.41, dividing
	.50, windows	.60, cell	.50, cell	.50, cell	.51, cell	.49, cell
	.47, doors	.60, cytoplasm	.48, cytoplasm	.49, cytoplasm	.51, cytoplasm	.48, cytoplasm
	.43, cytoplasm	.54, membrane	.44, organelles	.43, membrane	.43, sheetlike	.48, doors
	.43, unpainted	.52, organelles	.43, membrane	.43, organelles	.43, mitochondria	.47, door
	.42, cell	.50, protoplasm	.41, jail	.42, books	.43, organelles	.46, locked
	.42, bars	.49, mitochondria	.41, protoplasm	.42, mitochondria	.42, membrane	.45, sheetlike
	.41, window	.49, vacuoles	.40, mitochondria	.41, book	.42, vacuoles	.45, windows
	.40, locked	.49, outpouchings	.39, vacuoles	.40, protoplasm	.41, protoplasm	.44, opened
	.40, open	.49, infoldings	.39, outpouchings	.40, vacuoles	.41, windows	.44, vacuoles
	.39, expectin	.48, sheetlike	.39, infoldings	.40, windows	.40, bars	.44, boxes

	.75, mountain .70, peaks .69, mountains .60, ranges .60, 6684 .60, 6194 .60, 4418 .60, 2570 .60, 2037 .59, majesties	.83, mountain .79, peaks .78, mountains .69, ranges .68, 6684 .68, 6194 .68, 4418 .68, 2570 .68, 2037 .67, rugged	.79, mountain .73, peaks .73, mountains .66, 6684 .66, 6194 .66, 4418 .66, 2570 .66, 2037 .65, ranges .64, peak	.81, mountain .78, mountains .77, peaks .68, ranges .66, rugged .64, majesties .63, 6684 .63, 6194 .63, 4418 .63, 2570	.87, mountain .85, mountains .82, peaks .71, ranges .69, rugged .68, 6684 .68, 6194 .68, 4418 .68, 2570 .68, 2037	.77, mountain .73, mountains .71, peaks .67, majesties .62, ranges .62, 6684 .62, 6194 .62, 4418 .62, 2570 .62, 2037
	.51, ball .45, handoffs .44, salvadoreans .44, salvadorean .43, mitt .42, basketballs .42, midfield .41, midfielders .41, laterals .41, touchdown	.66, ball .54, handoffs .54, mitt .53, salvadoreans .53, salvadorean .53, downfield .53, midfielders .52, laterals .52, goalkeeper .52, midfield	.68, ball .55, mitt .54, bat .53, salvadoreans .53, salvadorean .52, umpire .51, catcher .50, midfielders .49, glove .49, throwing	.66, ball .55, salvadoreans .55, salvadorean .54, mitt .52, bat .51, umpire .50, goalie .49, fielder .49, touchdown .49, catcher	.70, ball .58, mitt .55, salvadoreans .55, salvadorean .55, catcher .55, bat .55, goalkeeper .55, downfield .53, umpire .53, handoffs	.68, ball .56, mitt .54, bat .54, catcher .53, salvadoreans .53, salvadorean .53, handoffs .52, goalkeeper .52, downfield .52, midfielders
	.66, bridge .51, railway .50, roebling .50, multispan .49, butts .48, bridges .47, catenary .46, roadways .46, loopholed .46, cantilever	.76, bridge .56, multispan .55, butts .53, railway .52, roebling .52, sentinels .51, loopholed .51, menai .51, brittannia .51, embrasure	.71, bridge .54, multispan .53, roebling .52, butts .51, railway .50, cantilever .50, loopholed .50, acclivity .50, embrasure .49, sentinels	.81, bridge .60, loopholed .60, acclivity .60, butts .60, multispan .59, embrasure .59, sentinels .58, crosstimber .58, executioners .58, cantilever	.80, bridge .61, multispan .59, butts .58, loopholed .58, acclivity .58, embrasure .57, executioners .57, cantilever .57, sentinels .57, crosstimber	.82, bridge .61, multispan .60, roebling .59, bridges .58, cantilever .56, catenary .56, paddlewheels .53, postbridge .52, springboards .52, anchorages
	.55, kite .52, saints .51, church .51, catholic .50, kites .50, flying .49, heretics .49, churches .48, christ .47, baptism	.68, kite .60, kites .58, fly .57, flying .51, gliders .51, glider .49, flew .47, wing .47, wright .47, orville	.63, kite .56, kites .42, flying .42, cross .39, fly .39, orville .38, lani .37, glider .37, gliders .37, flew	.66, kite .63, kites .52, fly .51, flying .45, glider .45, orville .45, gliders .42, lani .42, flew .42, church	.66, kite .59, kites .55, flying .50, fly .47, glider .44, gliders .44, orville .44, lani .43, flew .43, wing	.62, kite .54, kites .49, church .47, catholic .45, glider .45, flying .45, saints .45, heretics .45, zwinglians .45, zwingli
	.41, glass .38, window .36, diamond .35, windows .34, concave .34, refracted .33, beams .32, prism .32, bellying .32, prisms	.51, window .48, glass .42, windows .42, pane .37, sill .37, diamond .37, stone .35, staircase .35, polished .34, curtains	.39, diamond .36, 5x .36, 10x .36, magnifying .36, 1000x .34, lenses .34, stone .34, lens .33, prisms .33, magnifies	.59, glass .44, tube .44, window .42, stopper .38, tubes .37, stoppers .36, catnaps .35, stained .34, nosepiece .34, diamond	.41, green .41, ball .40, bat .38, hits .38, reflects .37, misplaying .37, handoffs .37, downfield .37, goalkeeper .36, mitt	.43, window .38, diamond .37, windows .36, glass .33, pane .33, intergrowths .33, cabochons .32, opal .32, frosted .31, annexe
	.45, nuclear .45, uranium .44, reactor .44, reactors .44, redoubling .44, alfven .44, hannes .44, radioactive .44, warhead .43, fallout	.47, fire .40, flames .37, fires .36, hearth .36, extinguisher .36, burning .35, evacuees .35, flame .34, sparks .34, flammable	.49, fire .48, radiation .44, gamma .43, emission .43, flames .42, successivly .42, mrem .42, millirem .42, 60ni .42, 60co	.42, wind .41, blowing .38, fire .37, propeller .35, windmill .34, turbine .34, blow .34, cross .33, flames .33, fallout	.56, uranium .56, radioactive .55, nuclear .55, reactors .53, reactor .53, 238u .52, radioactivity .52, redoubling .52, alfven .52, hannes	.53, nuclear .52, redoubling .52, alfven .52, hannes .49, reactor .48, reactors .48, fission .47, warhead .45, fissionable .45, uranium

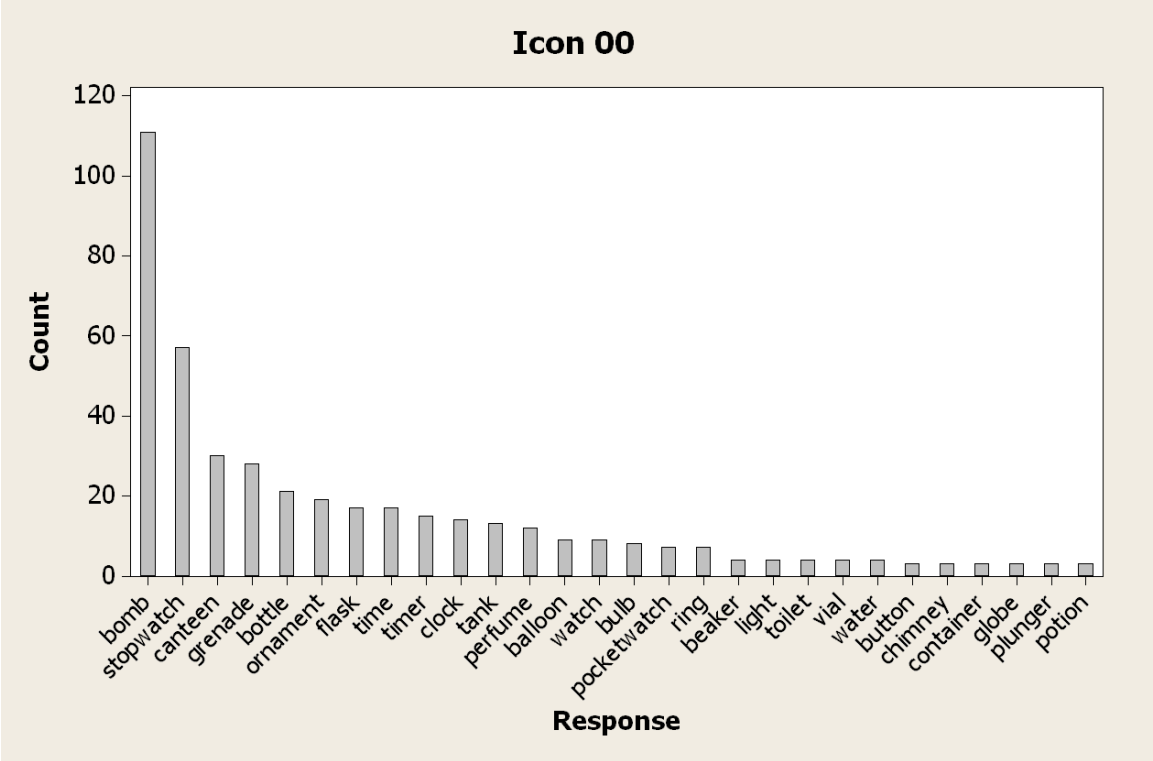
	.53, turn .46, left .43, direction .42, right .39, back .38, flashers .38, turning .38, go .37, cornering .37, reverse	.61, turn .47, left .44, kingpin .44, cornering .42, right .42, flashers .39, turns .38, reverse .37, direction .36, back	.62, turn .43, back .43, go .42, u .42, left .40, turns .39, turning .38, kingpin .36, around .36, cornering	.61, turn .47, left .43, right .40, turns .38, go .38, turning .37, cornering .37, u .37, back .35, kingpin	.62, turn .45, back .44, go .43, return .40, u .40, left .36, turns .36, turning .34, leave .34, blindspot	.58, turn .43, go .39, back .38, left .38, reverse .37, turns .37, u .37, flashers .35, blindspot .34, right
	.50, bag .45, lock .43, bags .39, locked .36, boxes .34, yellowjackets .34, button .32, safety .32, door .32, unlocking	.56, bag .56, lock .51, locked .47, open .44, door .42, bags .42, unlocked .42, opened .41, boxes .39, klang	.51, lock .48, bag .46, locked .39, yellowjackets .37, unlocked .37, boxes .36, door .36, purse .35, bags .34, suitcase	.58, lock .53, bag .48, key .44, locked .43, bags .41, keys .39, unlocked .38, unlock .36, door .34, purse	.52, bag .46, bags .42, lock .41, yellowjackets .36, boxes .34, tucked .33, wrapped .33, shopping .33, purse .32, magnetize	.54, bag .46, lock .44, bags .39, locked .37, opened .36, yellowjackets .35, shop .35, package .34, toilette .34, maniacally
	.54, microphone .51, studios .50, sound .49, film .48, filmed .47, cameras .47, films .47, tv .46, mgm .46, synchron-ization	.58, sound .53, microphone .49, louder .48, sounds .48, tmr .48, newscasts .47, acoustics .47, sonic .46, loudness .46, acoustical	.53, film .50, shutter .49, cameras .49, camera .49, sound .49, marey .49, lumiere .49, kinetoscope .49, films .48, studios	.55, film .53, sound .51, filmed .49, microphone .49, camera .49, studios .49, cameras .48, shutter .48, films .48, mgm	.51, sound .51, microphone .46, listener .46, listening .45, hear .45, listeners .45, ois .45, impeccably .45, speaker .45, louder	.55, microphone .53, film .51, cameras .51, studios .51, sound .50, filmed .49, camera .49, marey .49, lumiere .49, kinetoscope
	.47, headlights .46, car .43, parked .42, windshield .40, rearview .39, rear .38, dashboard .37, lights .37, sideswiped .37, curb	.54, car .43, parked .43, rearview .42, visors .42, windshield .41, roadster .41, white .41, black .40, dependably .39, dashboard	.46, pharmacist .45, pharmacists .44, medicine .44, prescription .44, car .43, emergency .42, medicines .41, doctor .40, treat .40, drugstores	.47, light .46, headlights .46, lights .44, beams .42, reflectors .40, mirrors .40, reflected .39, reflects .38, translucent .38, mirror	.57, headlights .53, car .47, windshield .46, rearview .43, driving .43, dashboard .42, oncoming .42, brakes .42, driver .41, dependably	.55, car .43, dependably .41, windshield .41, rearview .41, dashboard .41, parked .40, parking .40, brakes .39, headlights .39, blindspot
	.55, paint .45, painted .44, brush .44, cleaning .44, watercolor .44, flames .44, fire .44, painting .43, paints .43, burnish	.61, paint .54, cleaning .52, brush .51, clean .49, paints .48, fire .48, painting .48, impasto .47, fires .47, smother	.55, paint .53, clean .49, cleaning .48, brush .46, searchings .46, scratchboard .46, atists .46, painterly .46, artist .46, impasto	.53, paint .46, clean .44, cleaning .44, refinish .43, painted .43, rayed .42, brush .42, painters .42, recement .41, painting	.55, paint .46, brush .46, paints .46, watercolor .46, painted .43, colors .43, pigments .42, slipcover .42, cleaning .42, refinish	.59, fire .55, flames .53, fires .51, matches .51, match .51, smother .49, coals .49, extinguisher .48, flatirons .47, flammable
	.54, person .37, male .37, empathetic .37, orgasms .35, female .33, males .33, females .32, man .32, sex .32, mignon	.73, person .40, mignon .40, filet .39, extraverted .37, someone .36, ucla .36, stoller .36, ssv .36, sexiness .36, pleasureable	.69, person .38, empathetic .38,superabundant .38, preschools .38, homestart .38, gyny .37, male .37, someone .36, mignon .36, filet	.65, person .45, man .38, ucla .38, stoller .38, ssv .38, sexiness .38, pleasureable .38, agressive .38, fantasize .36, someone	.71, person .38, mignon .38, filet .38, empathetic .36, human .35, skiddley .35, shamrocks .35, handspring .35, broadwaller .35, eternity	.78, person .41, someone .38, zanna .36, extraverted .36, kilojoule .36, unfrocked .36, disarranged .36, blaspheming .35, retractions .35, defamatory

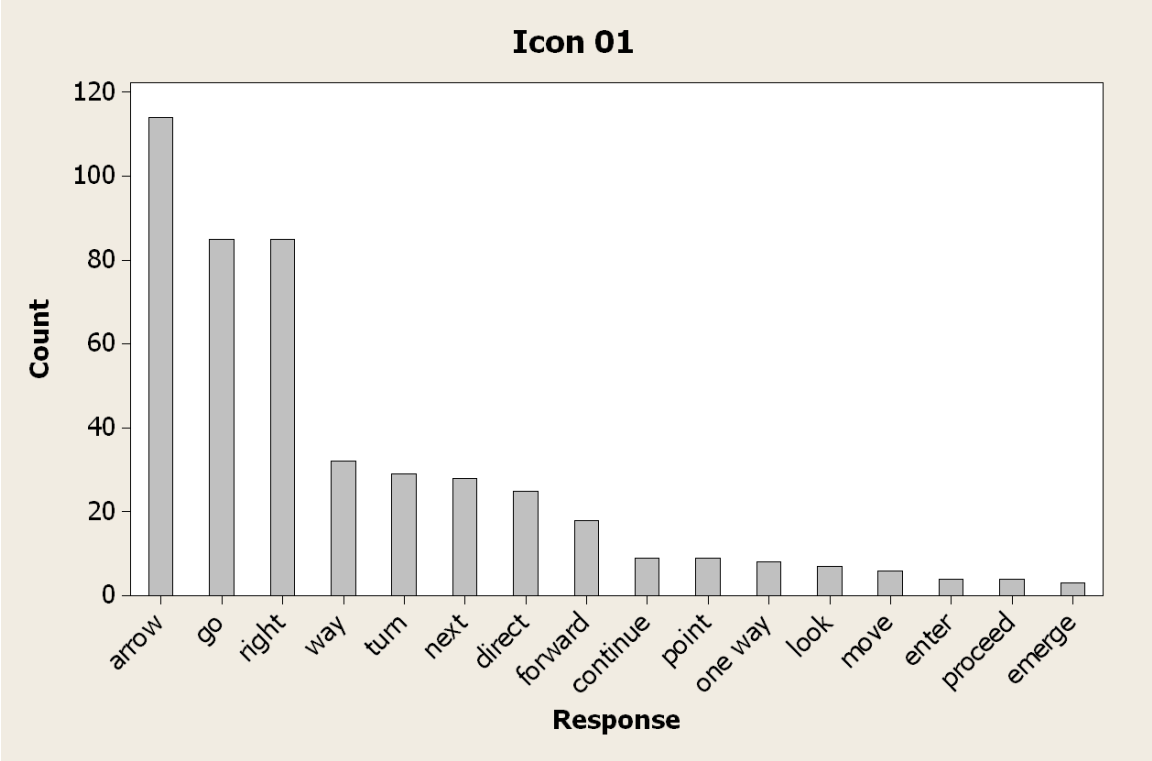
	.44, dog	.64, dog	.37, gloves	.50, dogs	.56, dog	.73, gold
	.42, leash	.57, barked	.35, caps	.50, dog	.50, dogs	.65, nuggets
	.42, standin	.56, wagging	.34, goshawks	.50, terrier	.49, leash	.61, silver
	.42, puppy	.55, leash	.34, jewelry	.49, puppy	.49, barked	.59, placer
	.42, lhasa	.54, collie	.34, crusted	.45, pets	.46, whup	.57, lode
	.42, wag	.54, dogs	.32, dresses	.44, wagging	.46, trousering	.56, marygold
	.42, dogs	.53, wag	.32, milverton	.44, starin	.46, fearenside	.56, bullion
	.41, terrier	.51, terrier	.32, dovercourt	.44, squealin	.46, terrier	.56, midas
	.39, ebbit	.51, puppy	.32, crunch	.44, howlin	.46, wag	.55, thiourea
	.39, barked	.49, lassie	.32, wearing	.44, growlin	.45, puppy	.55, 1849
	.62, key	.77, key	.72, key	.74, key	.69, key	.75, key
	.51, lock	.56, keys	.56, keys	.59, keys	.52, keys	.62, lock
	.51, keys	.51, iie	.47, lock	.56, lock	.44, bailees	.59, keys
	.44, bailees	.46, nonalphabetic	.41, iie	.44, unlock	.43, bailment	.52, locked
	.43, bailment	.44, cursor	.41, cursor	.43, nonalphabetic	.40, iie	.48, unlock
	.42, unlock	.44, lock	.40, locked	.43, cursor	.39, nonalphabetic	.46, door
	.41, locked	.42, uppercase	.40, nonalphabetic	.43, iie	.39, timeof	.44, unlocked
	.39, garage	.42, esc	.38, automatically	.42, bailees	.39, bailor	.42, car
	.37, car	.41, jloec	.38, ncr	.42, car	.37, uppercase	.42, bailees
	.37, windshield	.41, 39b	.38, jloec	.39, bailment	.37, deposit	.41, visors
	.52, waves	.44, eye	.52, waves	.61, waves	.57, waves	.63, waves
	.48, troughs	.39, 2	.50, troughs	.55, troughs	.49, vibrations	.57, crests
	.47, crests	.36, 1	.50, crests	.53, ripples	.49, vibration	.57, wave
	.44, wave	.36, 4	.45, wavelength	.52, hz	.48, vibrating	.57, troughs
	.44, wavelength	.35, 00007	.45, unpolarized	.51, crests	.48, troughs	.56, ripples
	.43, frequencies	.34, 3	.45, vibration	.51, curtails	.46, 2l	.53, crest
	.42, hertz	.34, eyes	.45, vibrations	.51, vibrations	.46, hertz	.51, unpolarized
	.42, superimposed	.33, presbyopia	.43, transverse	.51, vibration	.46, eardrum	.50, transverse
	.42, ripples	.33, 5	.43, light	.51, wave	.46, unpolarized	.49, wavelength
	.42, transverse	.33, eyeball	.43, vibrating	.51, hertz	.46, audible	.48, trough
	.46, disks	.45, disk	.39, disks	.45, disks	.44, shaft	.51, disk
	.45, disk	.44, disks	.37, disk	.45, disk	.44, flywheel	.49, disks
	.41, disc	.42, downshift	.36, records	.43, diskettes	.44, disc	.48, floppy
	.41, bytes	.41, bushing	.35, bytes	.42, replaceable	.43, crankshaft	.48, bytes
	.41, replaceable	.40, kickdown	.34, coils	.41, floppy	.43, clutch	.46, byte
	.40, clutch	.40, bytes	.34, accessing	.40, flywheel	.42, splines	.45, diskettes
	.40, splines	.39, retracts	.33, diskettes	.40, cassette	.42, crank	.43, keypunches
	.39, floppy	.39, byte	.33, hashing	.38, tape	.41, reinstallation	.42, tube
	.39, diskettes	.39, splines	.33, record	.38, bytes	.41, rotor	.41, peripherals
	.39, tape	.39, floppy	.33, tape	.38, impeller	.41, waukesha	.40, cpu
	.60, electricity	.56, lightning	.79, electricity	.63, electrical	.79, electricity	.63, lightning
	.58, electric	.50, electricity	.73, electric	.61, electricity	.73, electric	.63, electricity
	.58, electrical	.47, electrical	.69, lightning	.59, electric	.59, lightning	.52, thunderstorm
	.57, lightning	.45, thunderstorm	.61, electrical	.54, batteries	.58, kilowatt	.52, electric
	.49, batteries	.45, electric	.60, appliance	.54, generators	.58, electrical	.49, sparks
	.49, thunderstorm	.43, grounding	.59, alessandro	.53, volts	.58, appliance	.47, cabeo
	.47, kilowatt	.42, kilowatt	.59, shock	.53, generator	.56, shock	.46, shock
	.46, shock	.41, shock	.58, thunderstorm	.52, lightning	.56, chemcials	.46, alessandro
	.45, generators	.40, nondefective	.57, cabeo	.51, battery	.55, wires	.46, electrical
	.45, watts	.40, thunder	.57, wires	.48, kilowatt	.55, toaster	.45, chemcials
	.70, hz	.74, loudness	.71, hz	.68, loudness	.71, loudness	.70, antenna
	.70, frequency	.72, sound	.69, antenna	.68, sound	.69, sound	.69, kilohertz
	.69, antenna	.71, vibrating	.69, khz	.65, vibrating	.69, vibrating	.69, hertz
	.69, frequencies	.71, vibrations	.69, frequency	.65, vibrations	.68, vibrations	.68, hz
	.69, khz	.71, hz	.69, hertz	.64, kilohertz	.67, hz	.66, khz
	.68, loudness	.68, tuning	.68, loudness	.63, microphone	.66, tuning	.66, vibrating
	.68, hertz	.68, vibrate	.68, frequencies	.63, hertz	.66, vibrate	.65, radio
	.67, kilohertz	.68, vibrates	.67, kilohertz	.63, radio	.65, amplified	.65, vibrations
	.67, vibrating	.67, hertz	.67, amplitude	.63, antenna	.65, vibrates	.65, vibration
	.67, vibration	.67, vibration	.67, vibrations	.62, vibrate	.65, kilohertz	.65, frequencies

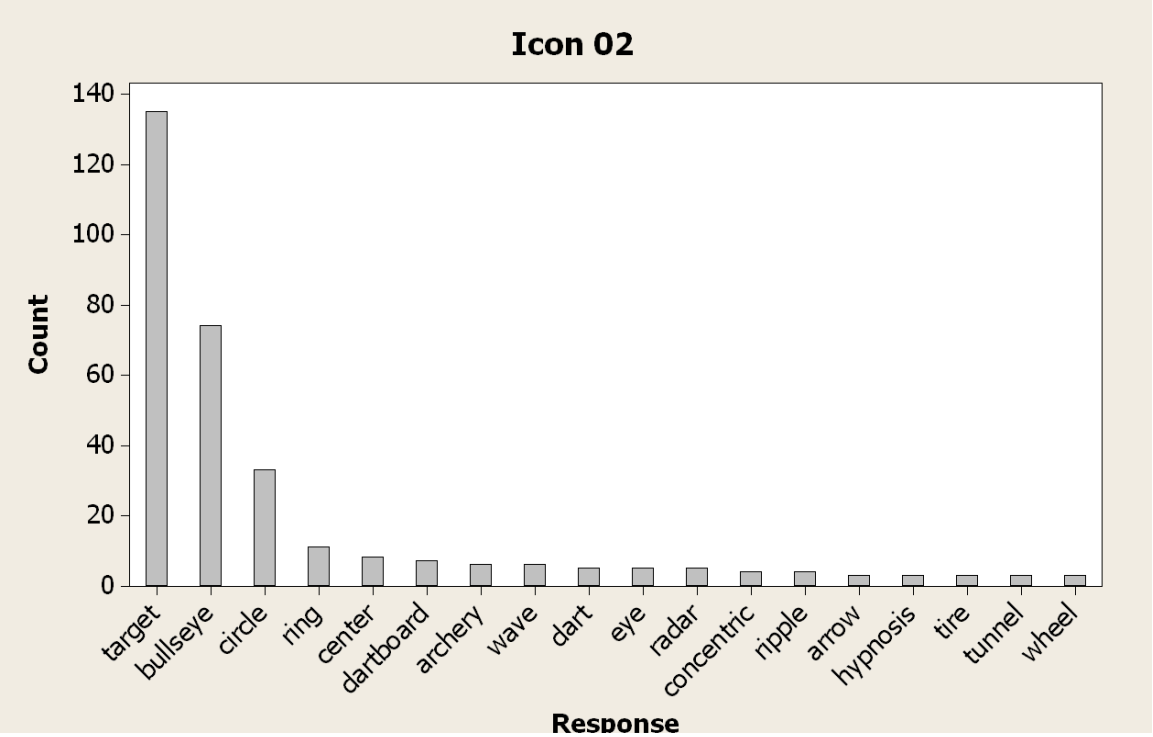
	.48, wheel	.62, wheel	.55, wheel	.51, wheel	.46, wheel	.53, light
	.48, orange	.54, axle	.47, wheels	.45, turn	.40, bright	.50, sun
	.43, bright	.52, wheels	.45, axle	.45, wheels	.39, gears	.44, shines
	.43, turn	.52, gearwheels	.45, gearwheels	.44, brightness	.39, vanes	.43, glow
	.42, brightness	.52, gearwheel	.45, gearwheel	.42, steering	.38, preload	.42, shine
	.42, wheels	.52, beater	.44, pedals	.41, axle	.38, brighter	.41, luminous
	.41, glow	.51, gears	.44, beater	.40, pedals	.38, brightness	.40, prominences
	.40, steering	.50, sprocket	.41, brightness	.39, gearwheels	.38, orange	.40, billionth
	.40, spectrums	.49, gear	.41, glow	.39, gearwheel	.38, denting	.40, incandescent
	.39, turning	.49, eggbeater	.41, crosspieces	.39, planetaries	.37, star	.40, taillights
	.49, fish	.73, fish	.64, fish	.56, fish	.50, waves	.68, fish
	.45, trout	.63, trout	.57, hook	.48, bluefish	.48, vibrating	.65, trout
	.45, hook	.62, herring	.57, trout	.48, mackerel	.48, vibration	.61, herring
	.43, vibration	.60, bass	.56, bait	.47, swordfish	.48, vibrations	.57, tuna
	.43, bluefish	.60, mackeral	.56, bluefish	.46, trout	.46, hertz	.57, mackerel
	.43, bait	.60, finfish	.55, herring	.45, tuna	.46, fish	.56, bluefish
	.42, bass	.59, tuna	.55, baited	.45, weakfish	.45, hz	.53, mackeral
	.42, herring	.59, bluefish	.54, mackerel	.45, blackfish	.45, 2l	.53, finfish
	.42, waves	.59, mackerel	.53, tuna	.45, herring	.45, curtails	.53, commpanies
	.42, vibrating	.57, bait	.50, scraggledy	.43, hagfish	.45, antinodes	.53, hook
	.57, seesaw	.63, balance	.60, balance	.59, balance	.61, balance	.61, balance
	.51, balance	.52, seesaw	.50, seesaw	.52, seesaw	.59, seesaw	.54, seesaw
	.48, weights	.49, balances	.46, weights	.52, dampers	.47, balanced	.49, balances
	.46, newtons	.40, fulcrum	.45, weight	.49, scale	.46, balances	.42, fulcrum
	.46, dampers	.39,encumbrances	.44, balanced	.49, balances	.45, weight	.40, balanced
	.46, weight	.38, ajdustments	.43, balances	.46, dynes	.45, newtons	.38, ageneral
	.44, fulcrum	.38, dampers	.41, newtons	.45, weights	.44, fulcrum	.38, entires
	.44, dynes	.37, asset	.40, dampers	.43, kilogram	.44, weights	.38,encumbrances
	.42, balanced	.37, scale	.38, dynes	.41, newtons	.42, ms2	.38, ajdustments
	.42, kilogram	.36, balanced	.38, pointer	.40, pointer	.41, dampers	.37, adjusting
	.54, play	.65, play	.66, play	.65, play	.65, play	.68, play
	.42, beiderbecke	.52, playing	.49, playing	.48, playing	.45, playing	.49, playing
	.42, playing	.47, beiderbecke	.43, plays	.48, beiderbecke	.44, playgoing	.45, plays
	.40, blues	.46, played	.42, right	.48, jazz	.44, stagehands	.45, playgoing
	.39, jazz	.44, timpani	.42, rehearses	.46, bandleader	.43, trevino	.43, costumes
	.39, banjo	.44, fidelia	.42, playgoing	.46, guitarists	.42, rehearses	.42, rehearses
	.38, polkas	.43, jazz	.42, costumes	.45, piano	.41, right	.42, trevino
	.38, stagehands	.43, autoharp	.41, kickball	.44, zinck	.40, costumes	.42, stagehands
	.38, rehearses	.43, bandleader	.40, trevino	.44, rangeview	.39, plays	.41, kickball
	.38, right	.43, bix	.40, watchable	.44, pleaser	.39, kickball	.40, actor

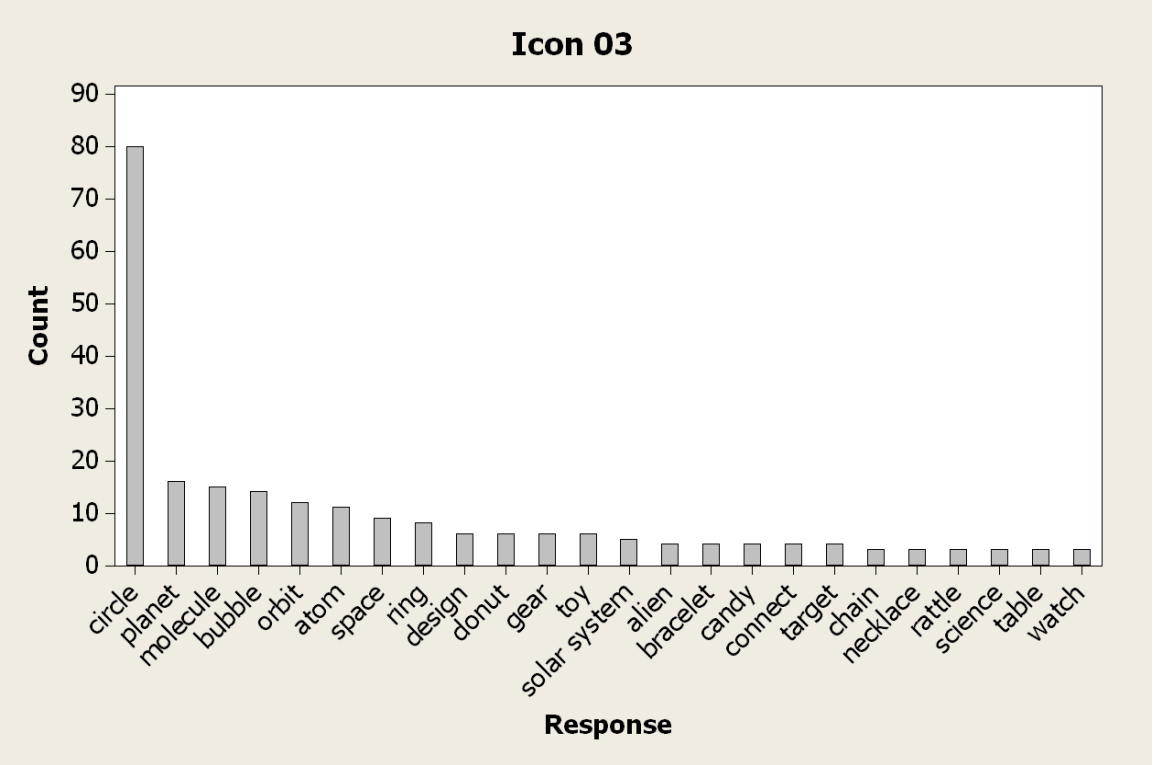
Graphs

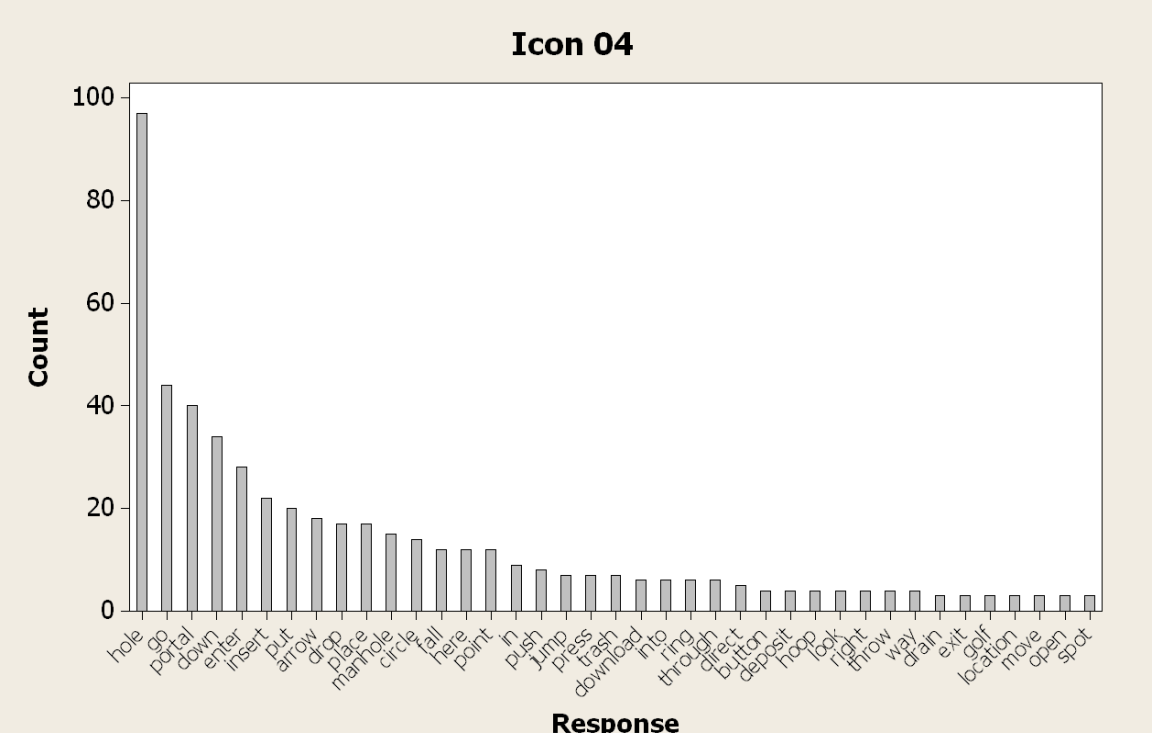
These graphs show the frequencies of responses greater than two for every icon. Most graphs have many responses that occurred once or twice. Analyzed below is the data which resulted after the responses were modified.

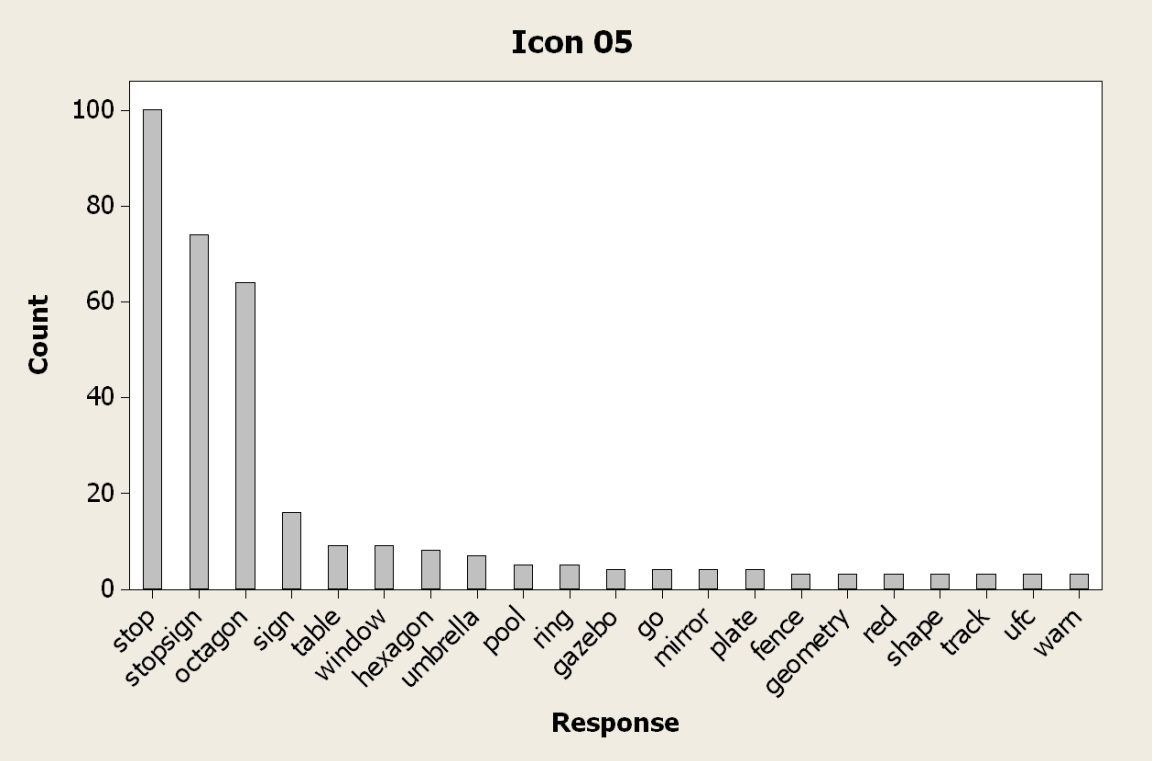

Icon 00
Count
120
100
80
60
40
20
0
bomb
stopwatch
canteen
grenade
bottle
ornament
flask
time
timer
clock
tank
perfume
balloon
watch
bulb
pocketwatch
ring
beaker
light
toilet
vial
water
button
chimney
container
globe
plunger
potion
Response

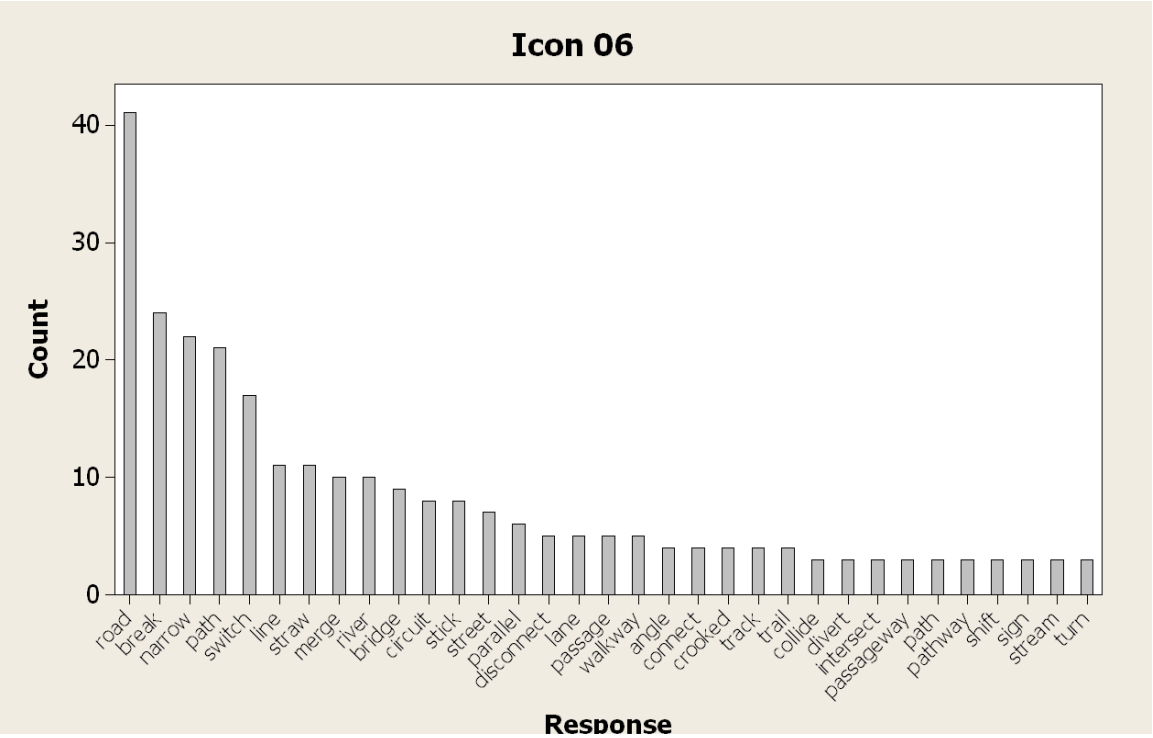

Icon 01
Count
120
100
80
60
40
20
0
arrow
go
right
way
turn
next
direct
forward
continue
point
one way
look
move
enter
proceed
emerge
Response

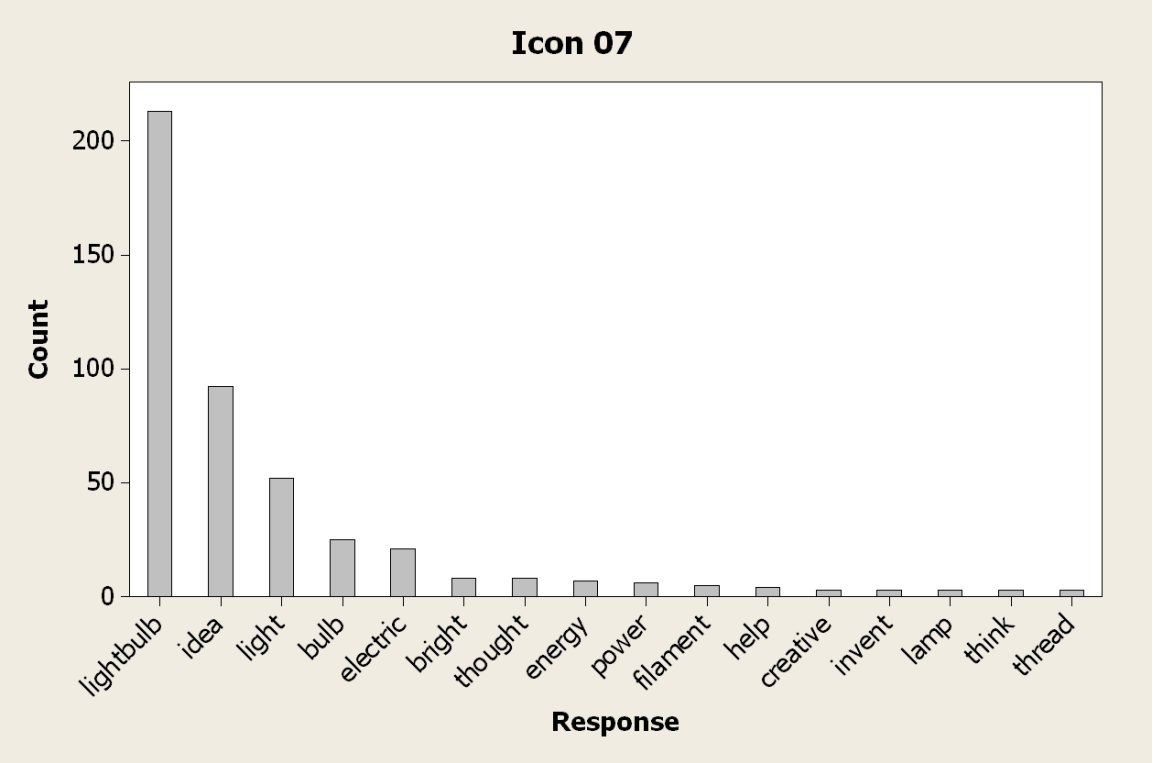

Icon 02
Count
140
120
100
80
60
40
20
0
target
bullseye
circle
ring
center
dartboard
archery
wave
dart
eye
radar
concentric
ripple
arrow
hypnosis
tire
tunnel
wheel
Response

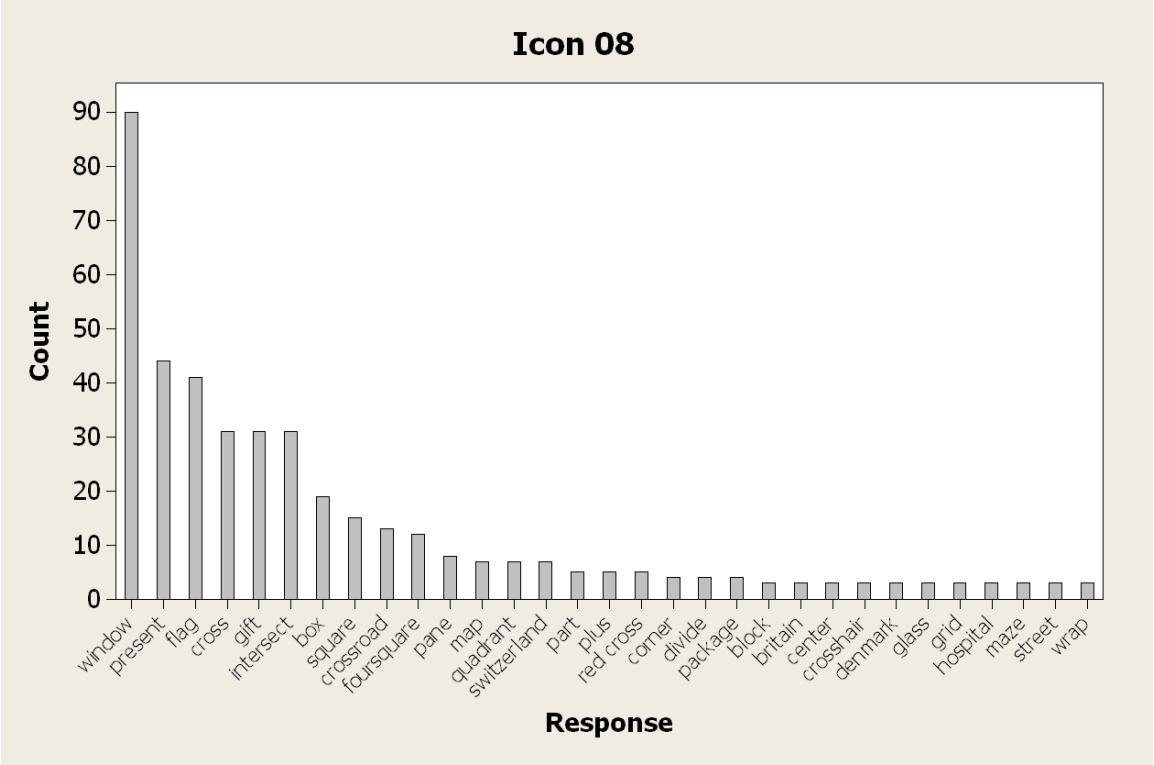

Icon 03
Count
90
80
70
60
50
40
30
20
10
0
circle
planet
molecule
bubble
orbit
atom
space
ring
design
donut
gear
toy
solar system
alien
bracelet
candy
connect
target
chain
necklace
rattle
science
table
watch
Response

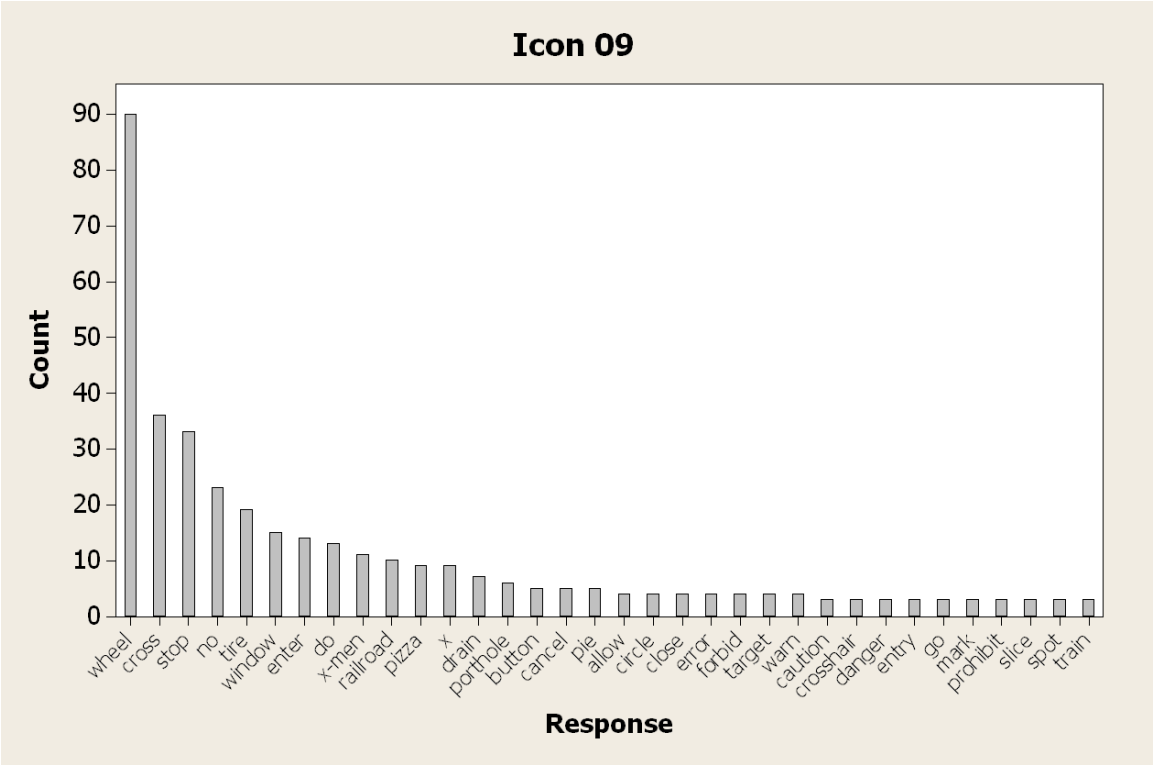

Icon 04
Count
100
80
60
40
20
0
hole
go
portal
down
enter
insert
put
arrow
drop
place
manhole
circle
fall
here
point
in
push
jump
press
trash
download
into
ring
through
direct
button
deposit
hoop
look
right
throw
way
drain
exit
golf
location
move
open
spot
Response

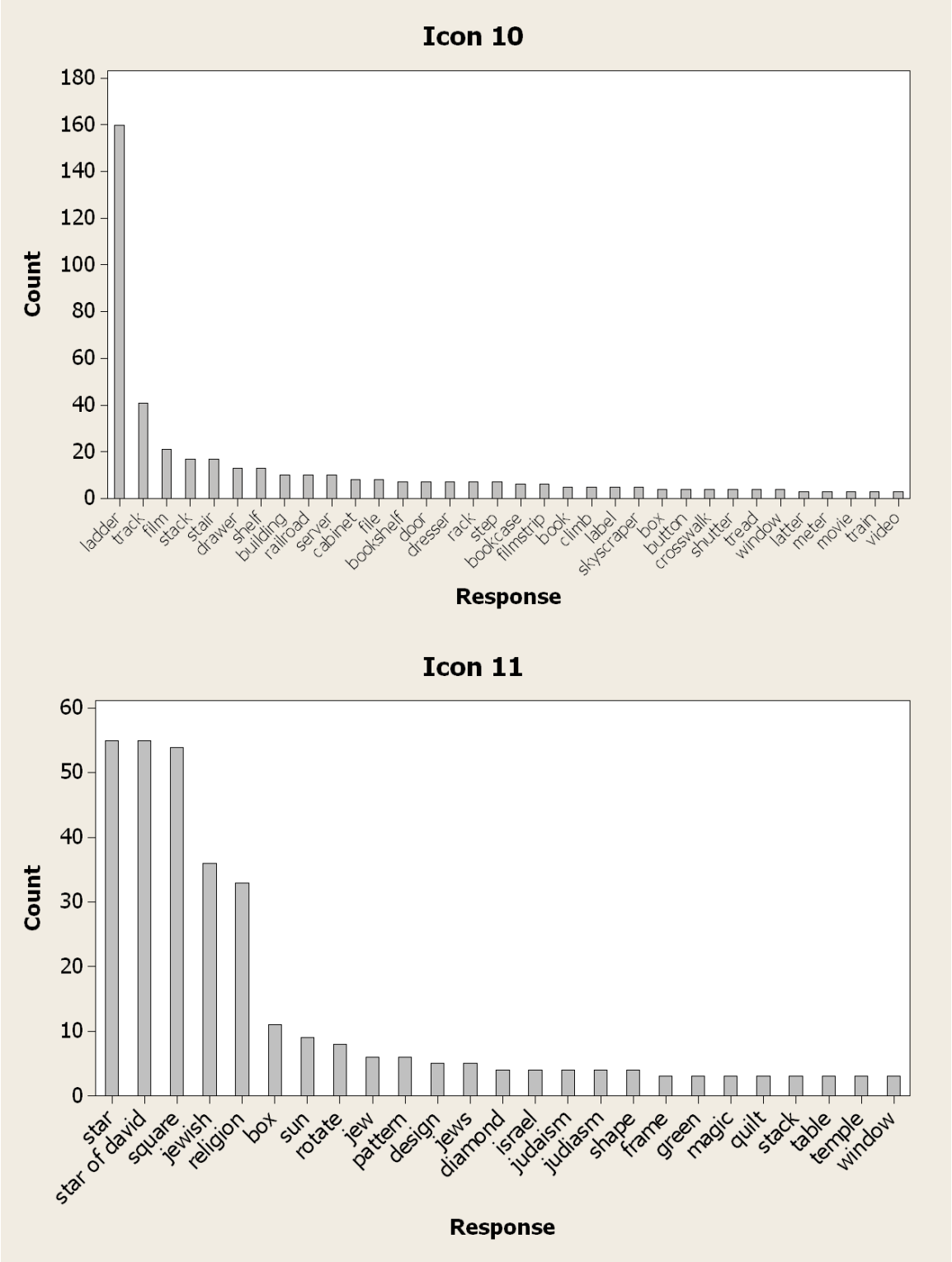

Icon 05
Count
100
80
60
40
20
0
stop
stopsign
octagon
sign
table
window
hexagon
umbrella
pool
ring
gazebo
go
mirror
plate
fence
geometry
red
shape
track
ufc
warn
Response

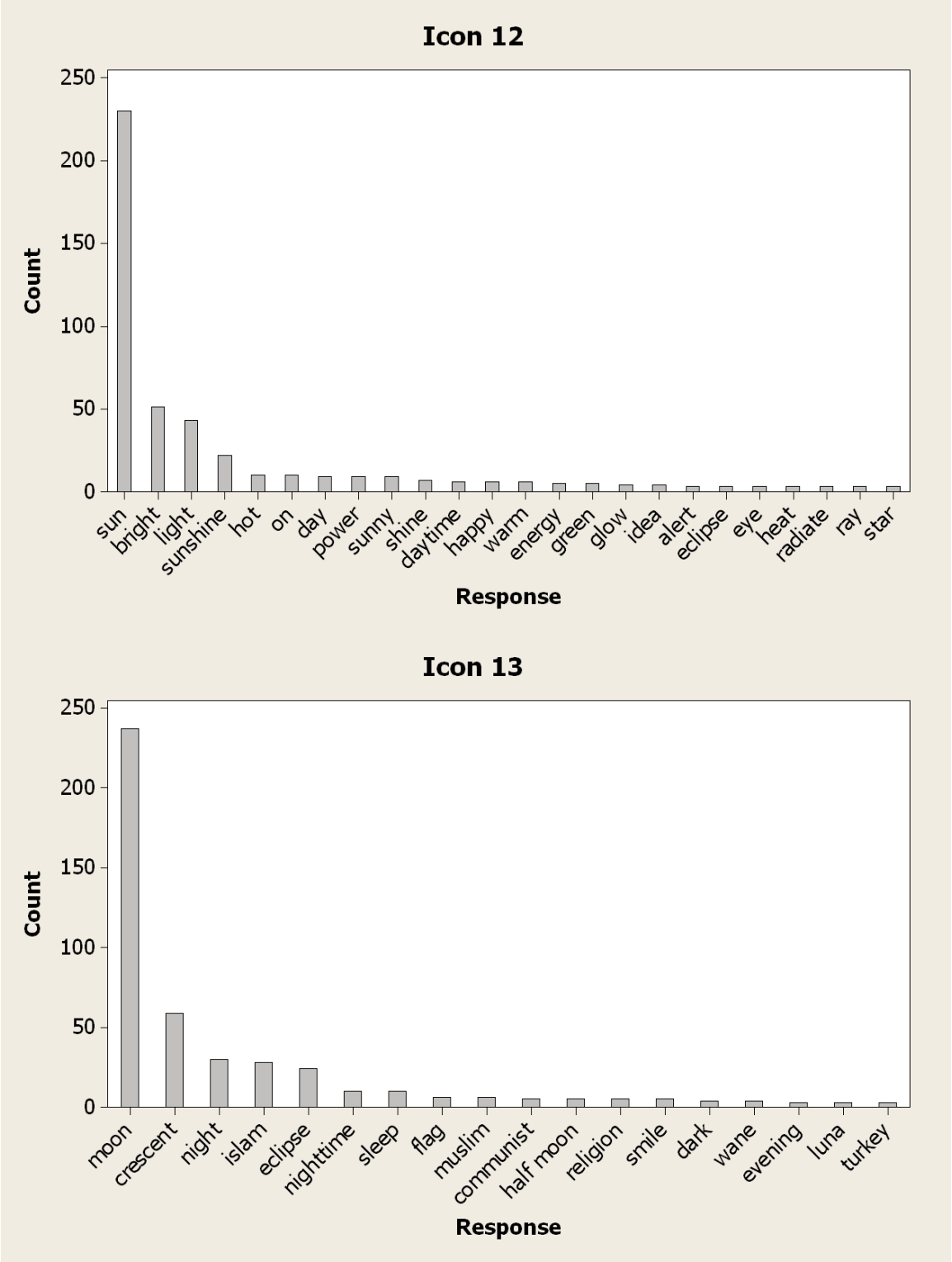

Icon 06
Count
0
10
20
30
40
road
break
narrow
path
switch
line
straw
merge
river
bridge
circuit
stick
street
parallel
disconnect
lane
passage
walkway
angle
connect
crooked
track
trail
collide
divert
intersect
passageway
path
pathway
shift
sign
stream
turn
Response

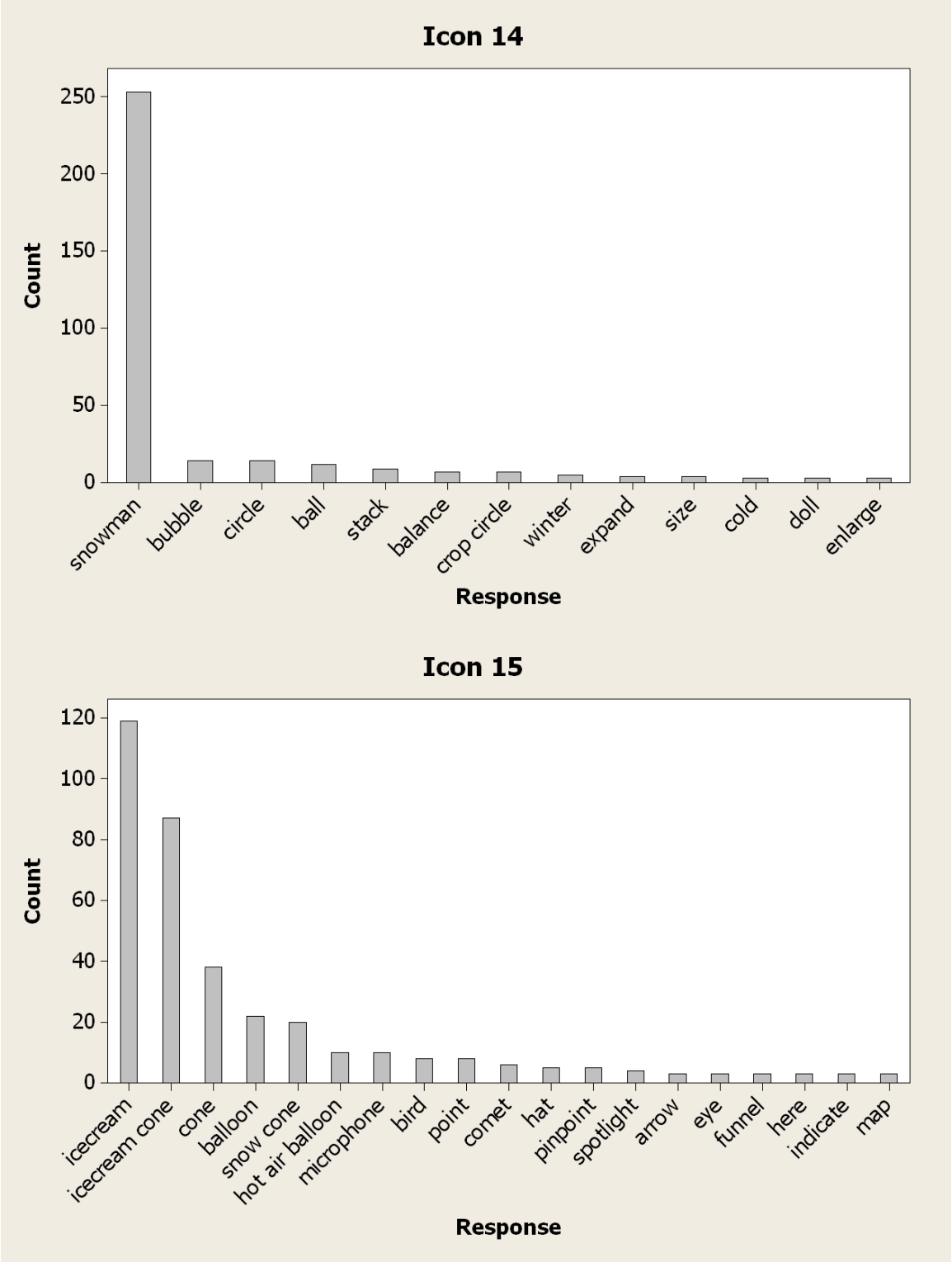

Icon 07
Count
0
50
100
150
200
lightbulb
idea
light
bulb
electric
bright
thought
energy
power
filament
help
creative
invent
lamp
think
thread
Response

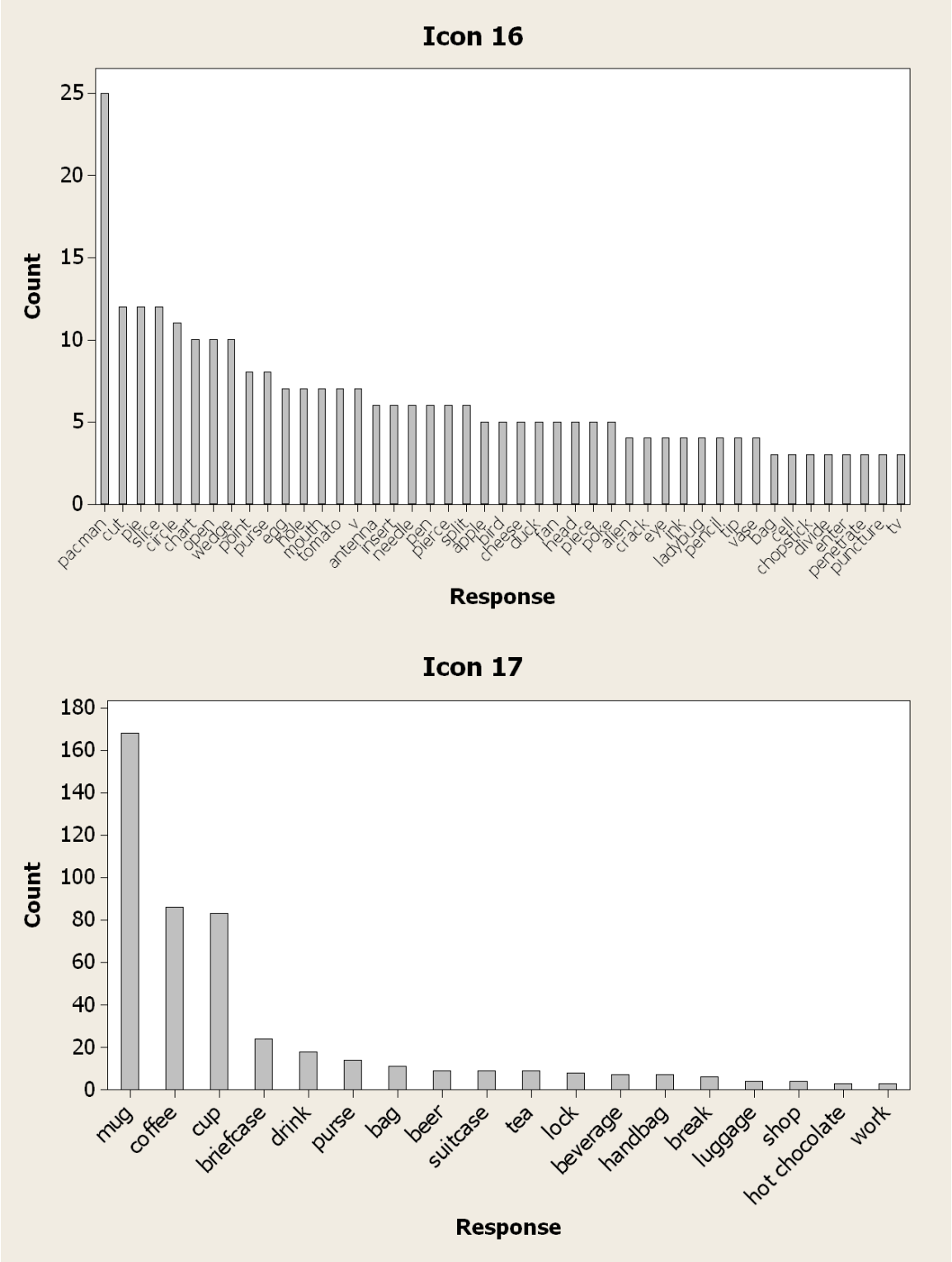

Icon 08
Count
0
10
20
30
40
50
60
70
80
90
window
present
flag
cross
gift
intersect
box
square
crossroad
foursquare
pane
map
quadrant
switzerland
part
plus
red cross
corner
divide
package
block
britain
center
crosshair
denmark
glass
grid
hospital
maze
street
wrap
Response

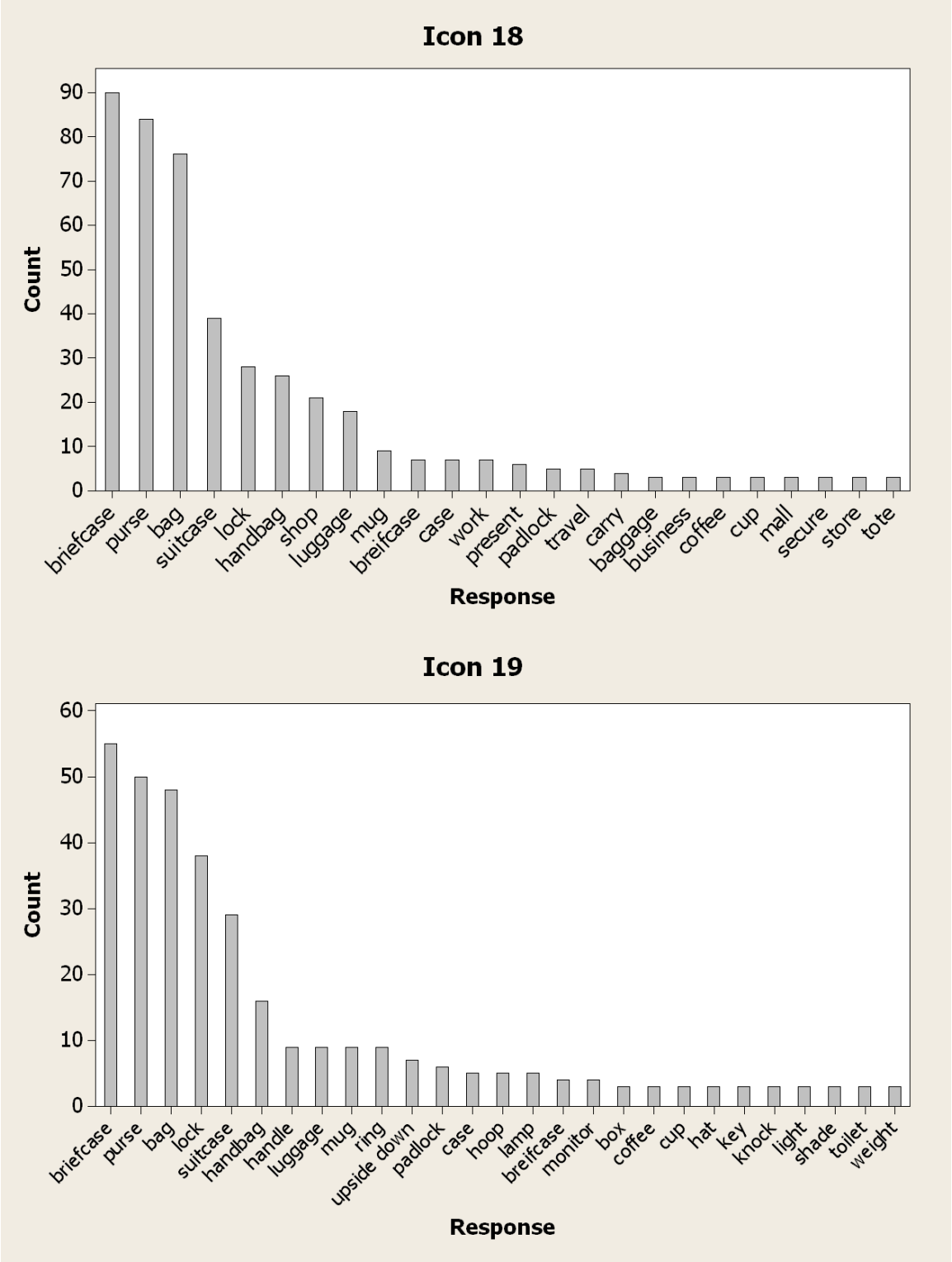

Icon 09
Count
0
10
20
30
40
50
60
70
80
90
wheel
cross
stop
no
tire
window
enter
do
x-men
railroad
pizza
x
drain
porthole
button
cancel
pie
allow
circle
close
error
forbid
target
warn
caution
crosshair
danger
entry
go
mark
prohibit
slice
spot
train
Response

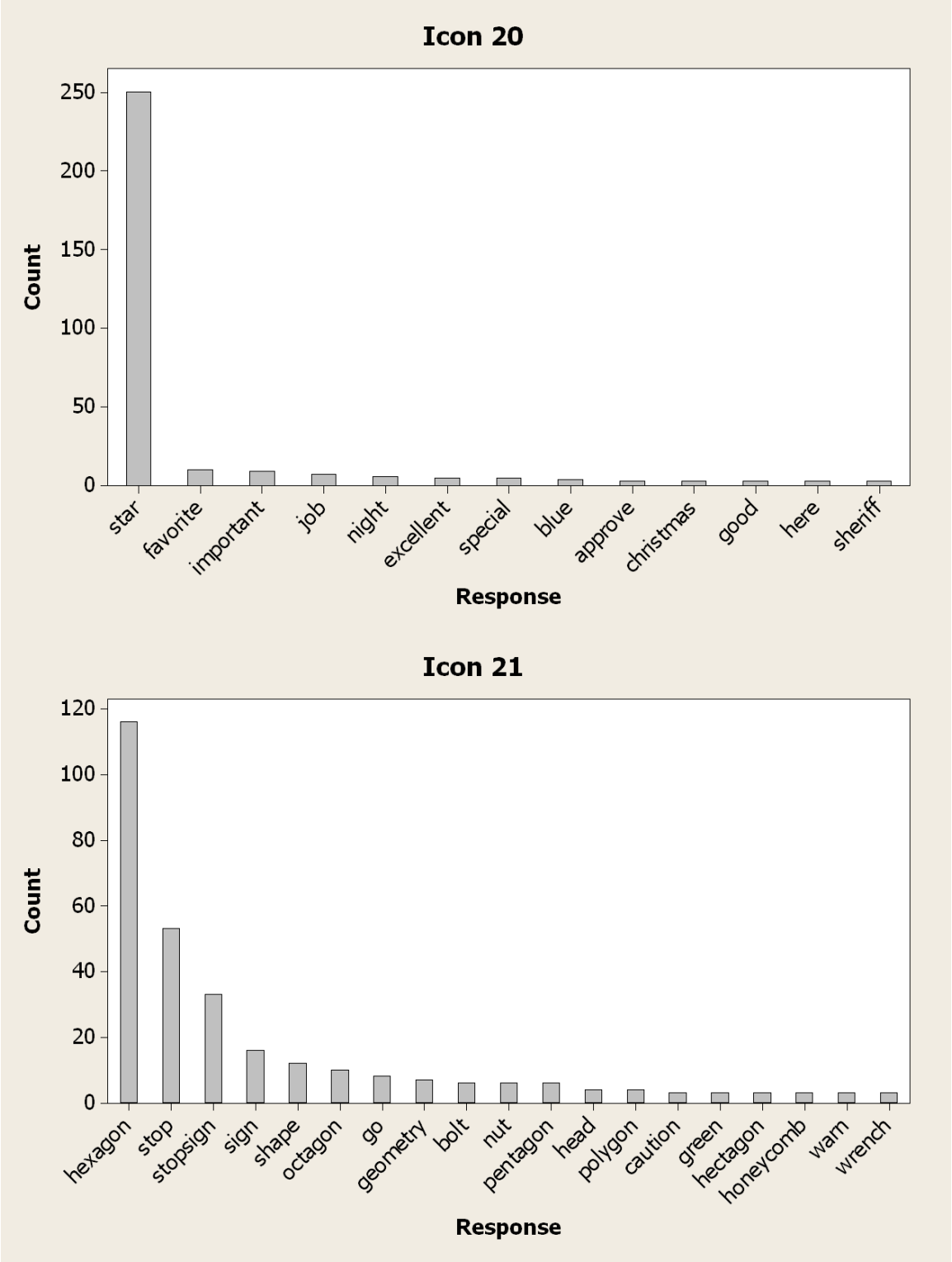

Icon 10
Count
180
160
140
120
100
80
60
40
20
0
ladder
track
film
stack
stair
drawer
shelf
building
railroad
server
cabinet
file
bookshelf
door
dresser
rack
step
bookcase
filmstrip
book
climb
label
skyscraper
box
button
crosswalk
shutter
tread
window
latter
meter
movie
train
video
Response
Icon 11
Count
60
50
40
30
20
10
0
star
star of david
square
jewish
religion
box
sun
rotate
jew
pattern
design
jews
diamond
israel
judaism
judiasm
shape
frame
green
magic
quilt
stack
table
temple
window
Response

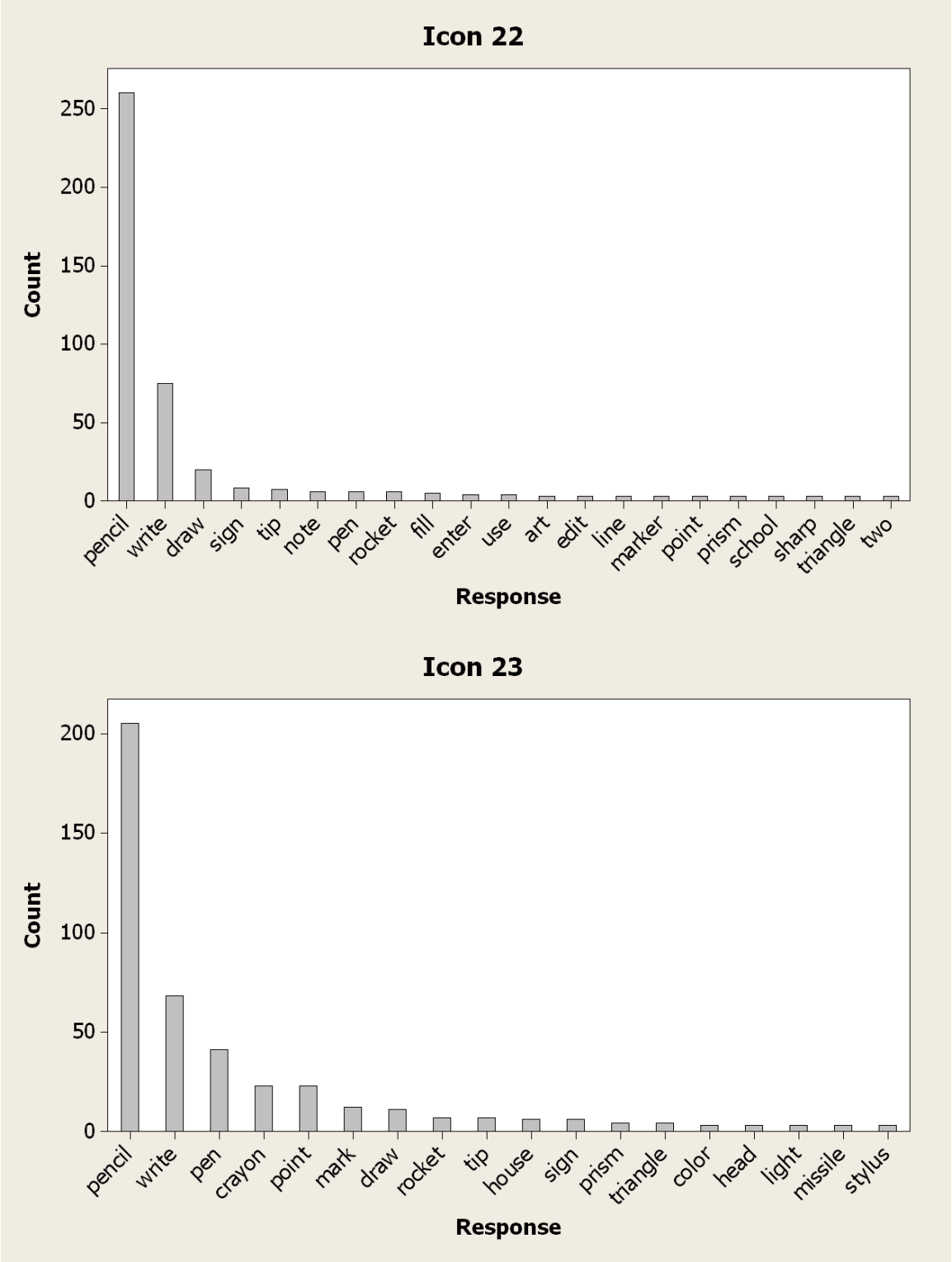

Icon 12
Count
250
200
150
100
50
0
sun
bright
light
sunshine
hot
on
day
power
sunny
shine
daytime
happy
warm
energy
green
glow
idea
alert
eclipse
eye
heat
radiate
ray
star
Response
Icon 13
Count
250
200
150
100
50
0
moon
crescent
night
islam
eclipse
nighttime
sleep
flag
muslim
communist
half moon
religion
smile
dark
wane
evening
luna
turkey
Response

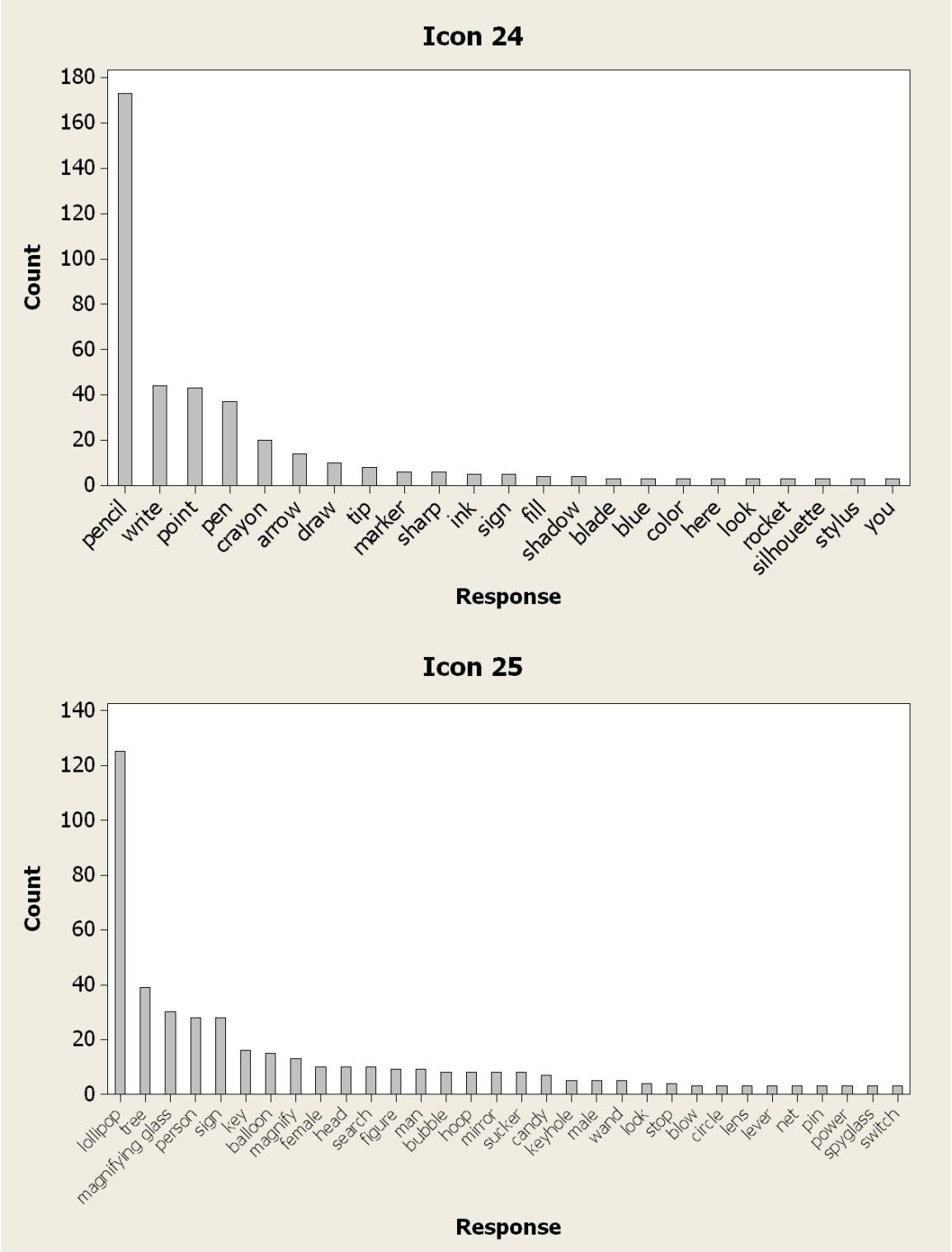

Icon 14
Count
250
200
150
100
50
0
snowman
bubble
circle
ball
stack
balance
crop circle
winter
expand
size
cold
doll
enlarge
Response
Icon 15
Count
120
100
80
60
40
20
0
icecream
icecream cone
cone
balloon
snow cone
hot air balloon
microphone
bird
point
comet
hat
pinpoint
spotlight
arrow
eye
funnel
here
indicate
map
Response

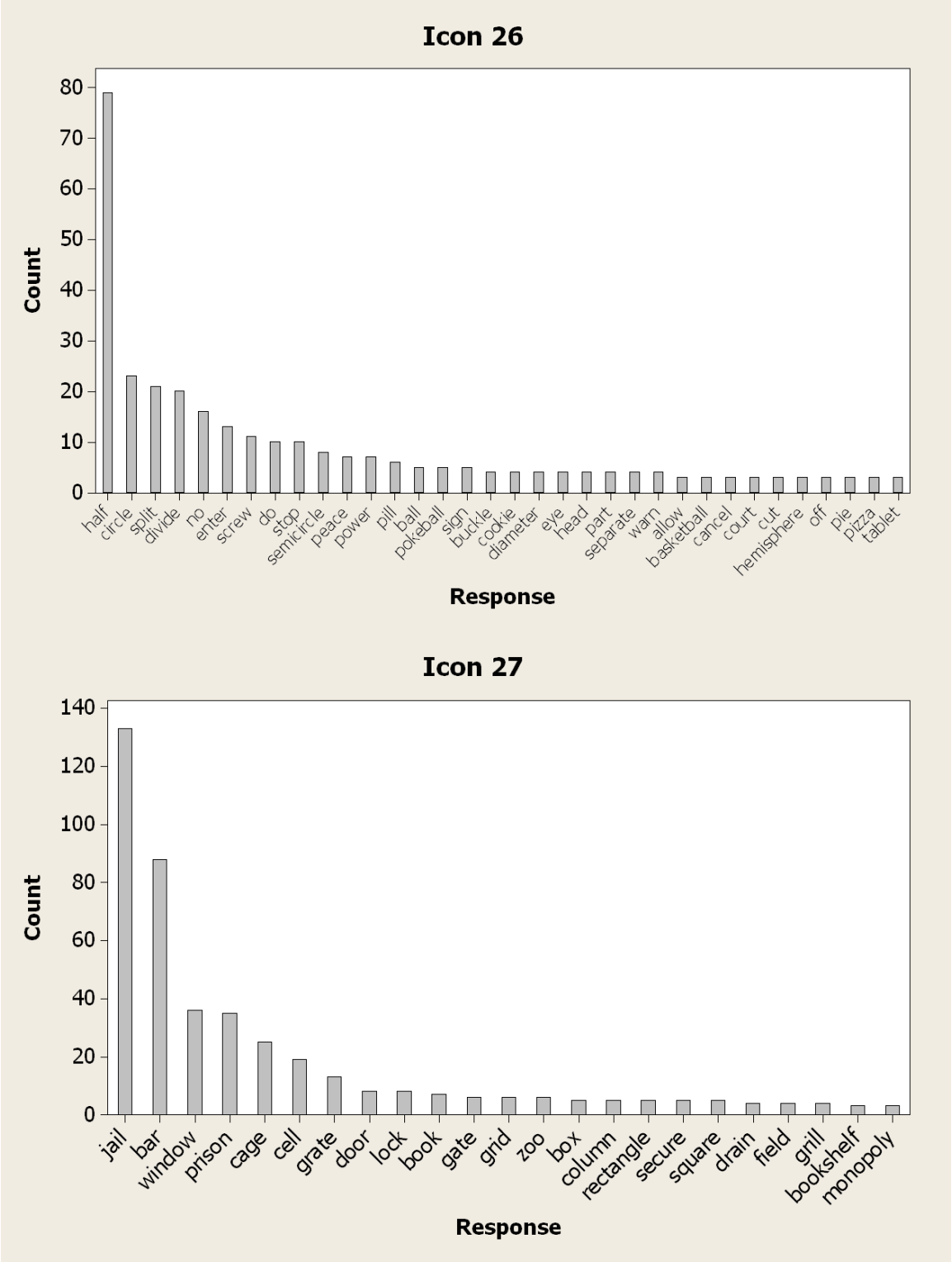

Icon 16
Count
Response
pacman
cut
pie
slice
circle
chart
open
wedge
point
purse
egg
hole
mouth
tomato
v
antenna
insert
needle
pen
pierce
split
apple
bird
cheese
duck
fan
head
piece
poke
alien
crack
eye
ink
ladybug
pencil
tip
vase
bag
cell
chopstick
divide
enter
penetrate
puncture
tv
Icon 17
Count
Response
mug
coffee
cup
briefcase
drink
purse
bag
beer
suitcase
tea
lock
beverage
handbag
break
luggage
shop
hot chocolate
work

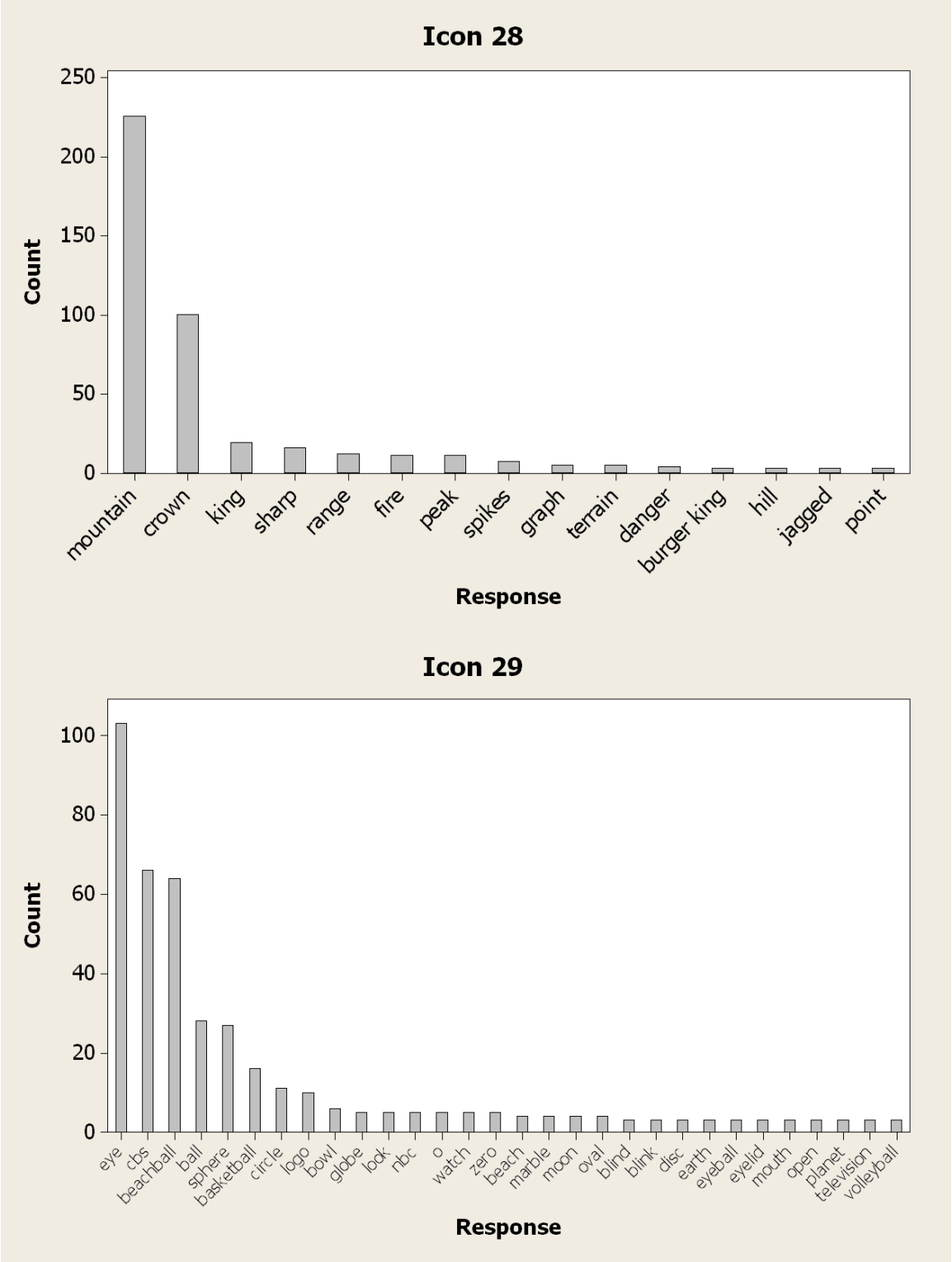

Icon 18
Count
0
10
20
30
40
50
60
70
80
90
briefcase
purse
bag
suitcase
lock
handbag
shop
luggage
mug
breifcase
case
work
present
padlock
travel
carry
baggage
business
coffee
cup
mall
secure
store
tote
Response
Icon 19
Count
0
10
20
30
40
50
60
briefcase
purse
bag
lock
suitcase
handbag
handle
luggage
mug
ring
upside down
padlock
case
hoop
lamp
breifcase
monitor
box
coffee
cup
hat
key
knock
light
shade
toilet
weight
Response

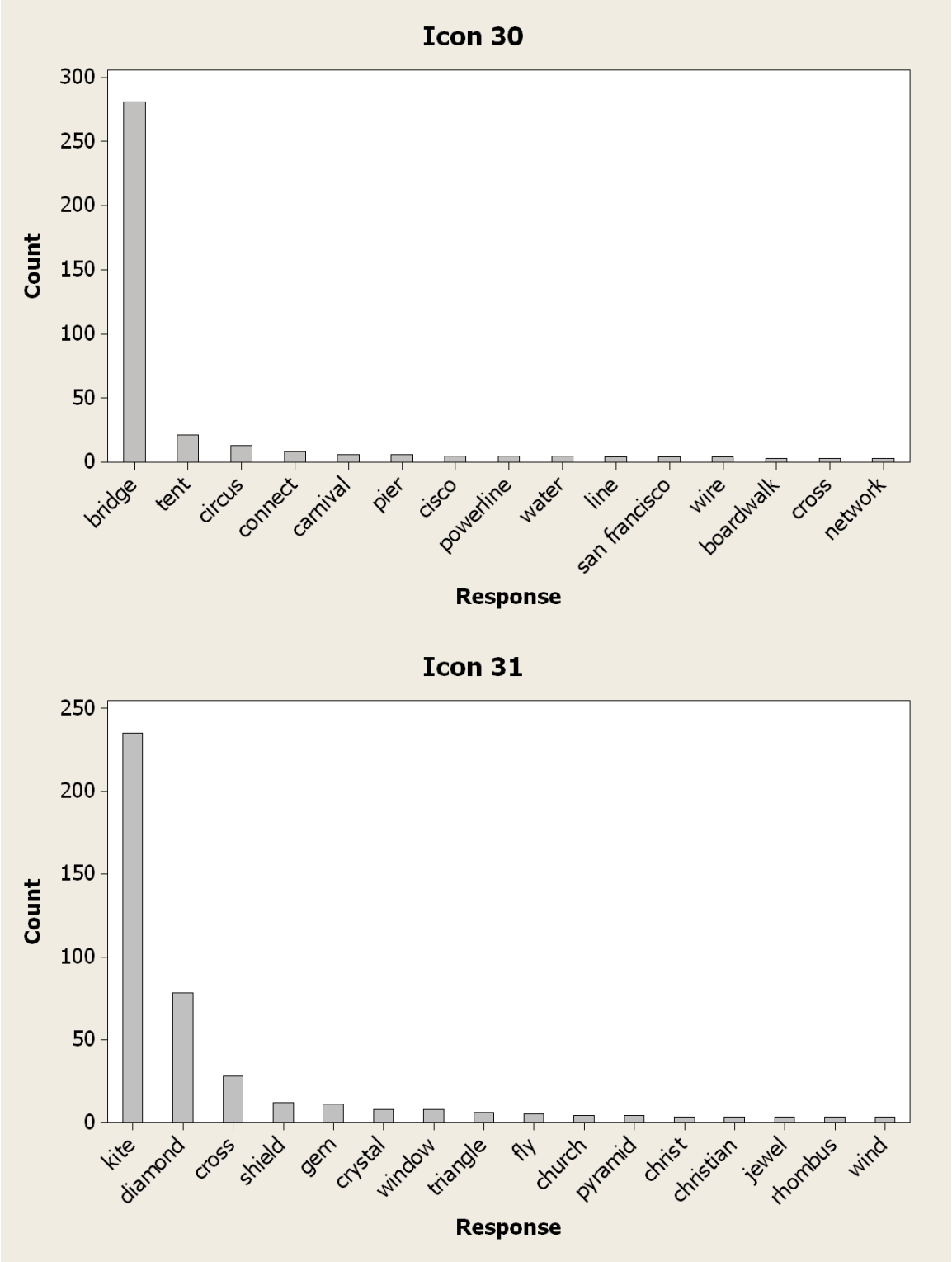

Icon 20
Count
250
200
150
100
50
0
star
favorite
important
job
night
excellent
special
blue
approve
christmas
good
here
sheriff
Response
Icon 21
Count
120
100
80
60
40
20
0
hexagon
stop
stopsign
sign
shape
octagon
go
geometry
bolt
nut
pentagon
head
polygon
caution
green
hectagon
honeycomb
warn
wrench
Response

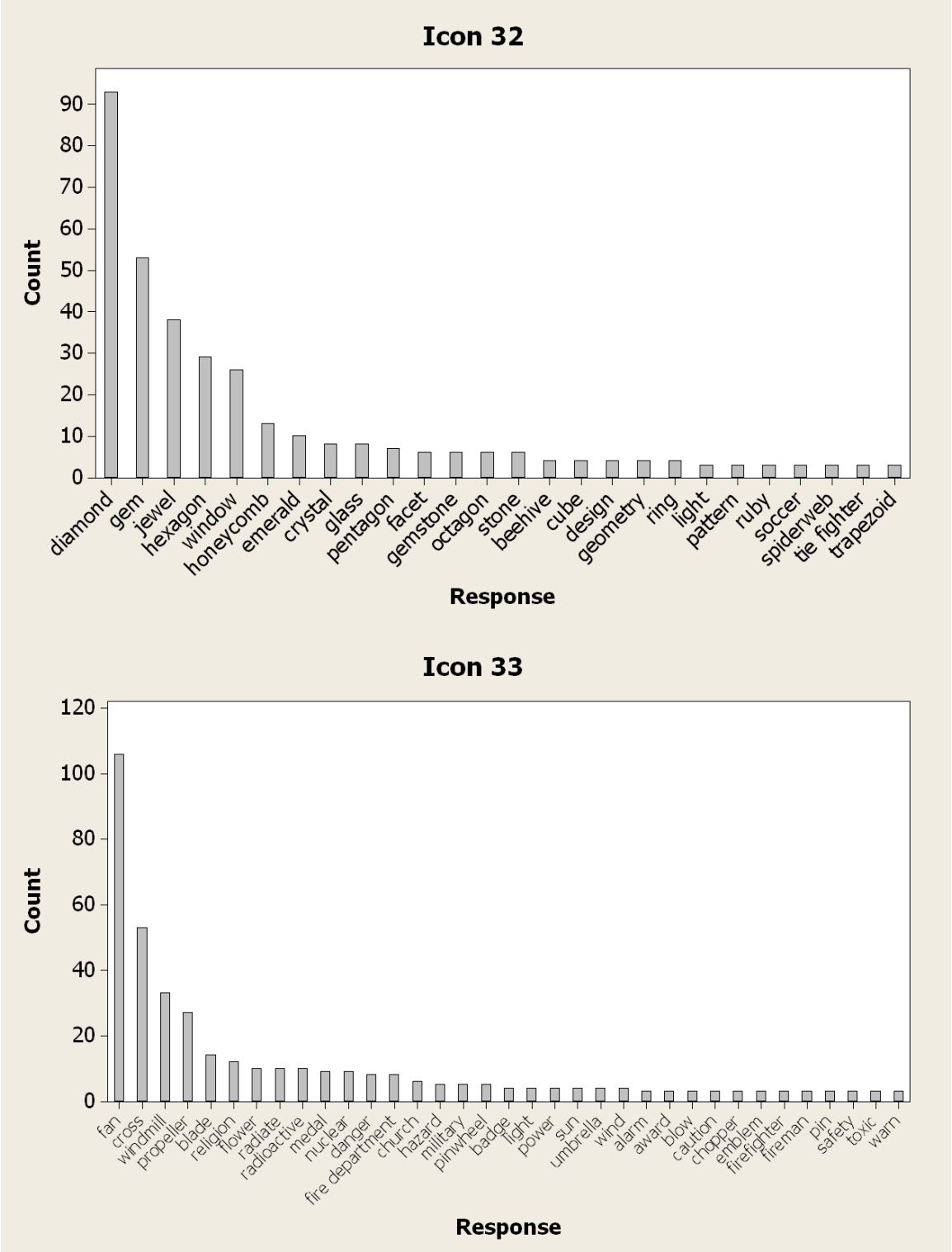

Icon 22
Count
250
200
150
100
50
0
pencil
write
draw
sign
tip
note
pen
rocket
fill
enter
use
art
edit
line
marker
point
prism
school
sharp
triangle
two
Response
Icon 23
Count
200
150
100
50
0
pencil
write
pen
crayon
point
mark
draw
rocket
tip
house
sign
prism
triangle
color
head
light
missile
stylus
Response

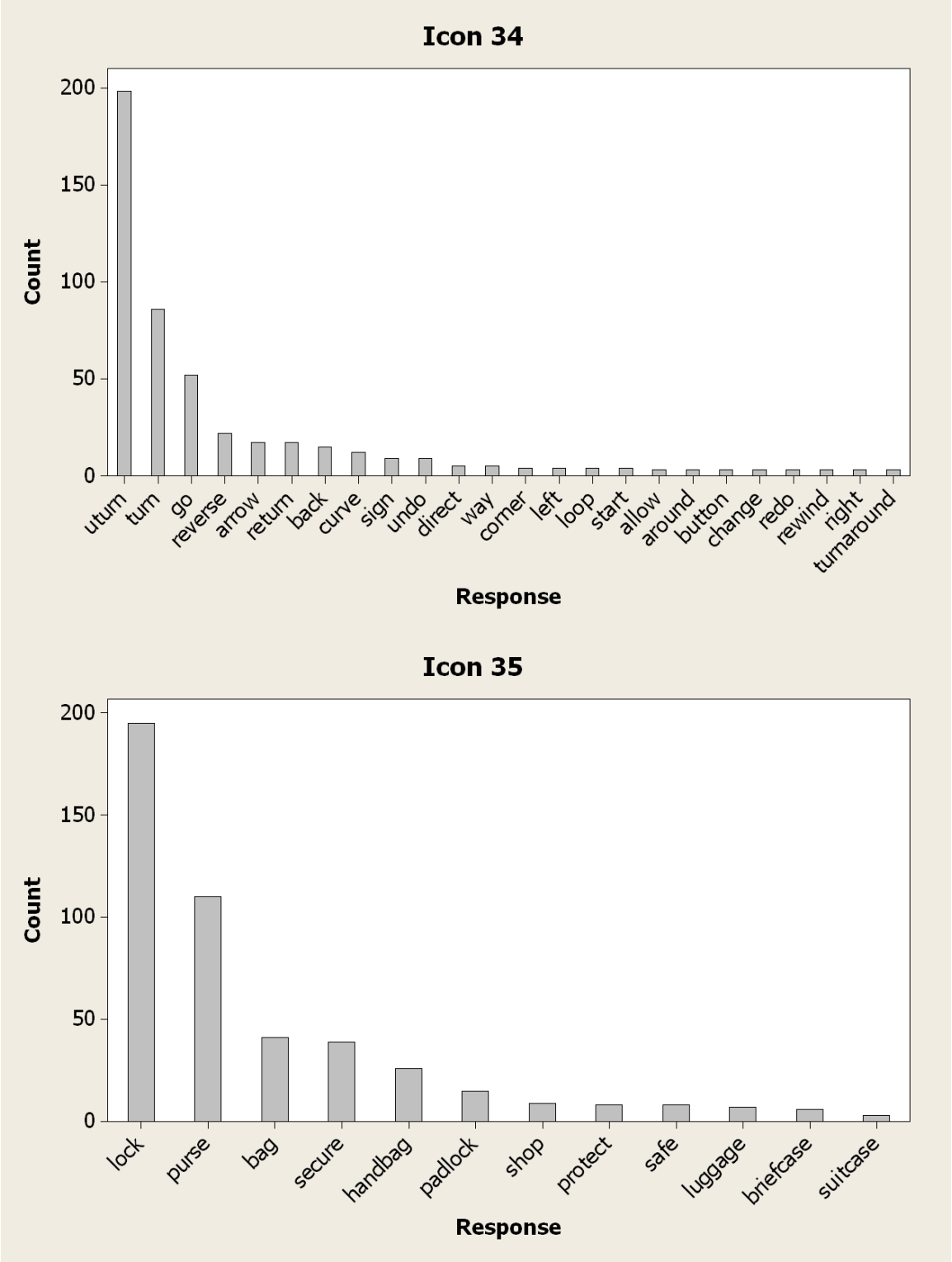

Icon 24
Count
180
160
140
120
100
80
60
40
20
0
pencil
write
point
pen
crayon
arrow
draw
tip
marker
sharp
ink
sign
fill
shadow
blade
blue
color
here
look
rocket
silhouette
stylus
you
Response
Icon 25
Count
140
120
100
80
60
40
20
0
lollipop
tree
magnifying glass
person
sign
key
balloon
magnify
female
head
search
figure
man
bubble
hoop
mirror
sucker
candy
keyhole
male
wand
look
stop
blow
circle
lens
lever
net
pin
power
spyglass
switch
Response

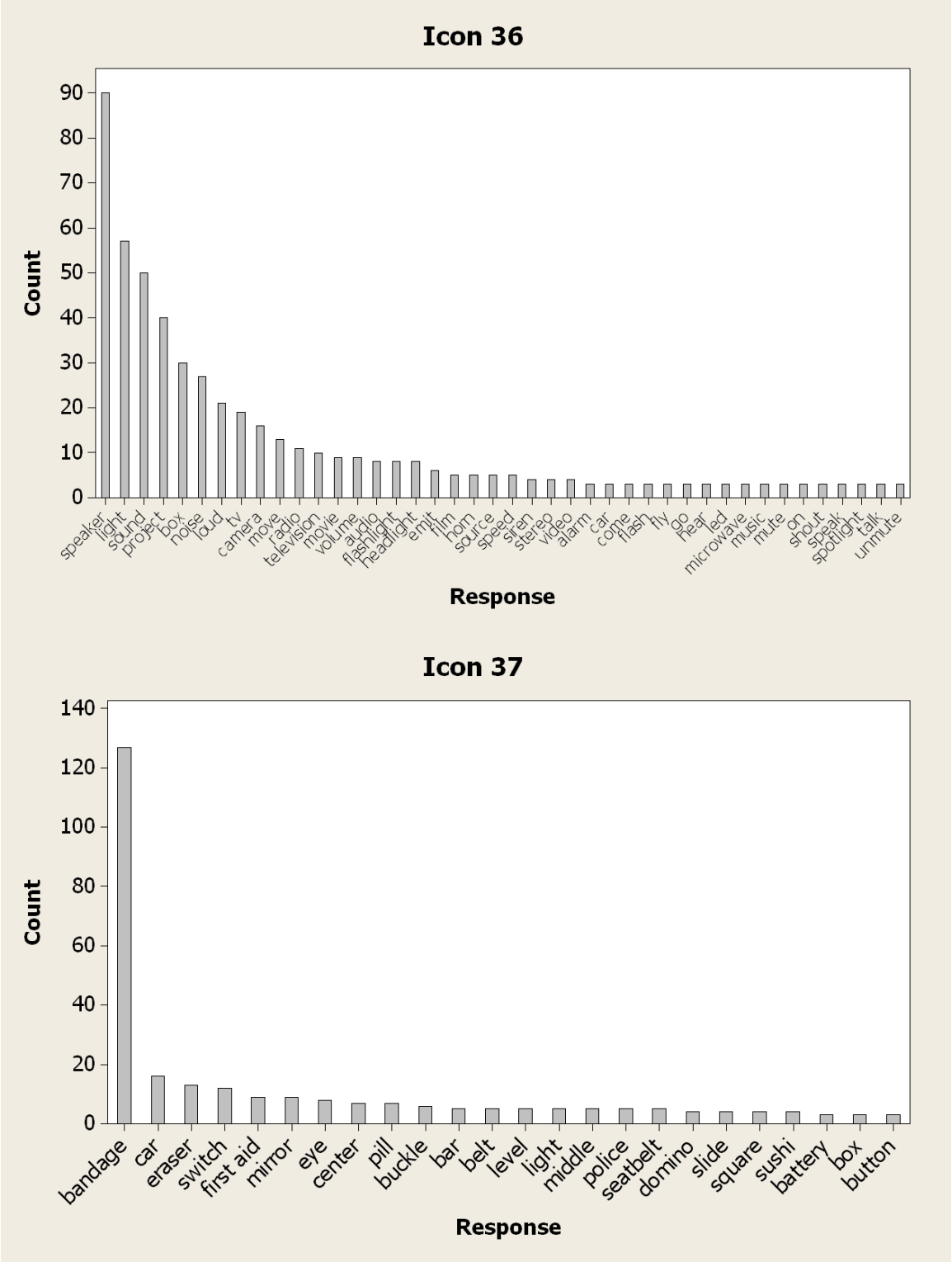

Icon 26
Count
Response
half
circle
split
divide
no
enter
screw
do
stop
semicircle
peace
power
pill
ball
pokeball
sign
buckle
cookie
diameter
eye
head
part
separate
warn
allow
basketball
cancel
court
cut
hemisphere
off
pie
pizza
tablet
Icon 27
Count
Response
jail
bar
window
prison
cage
cell
grate
door
lock
book
gate
grid
zoo
box
column
rectangle
secure
square
drain
field
grill
bookshelf
monopoly

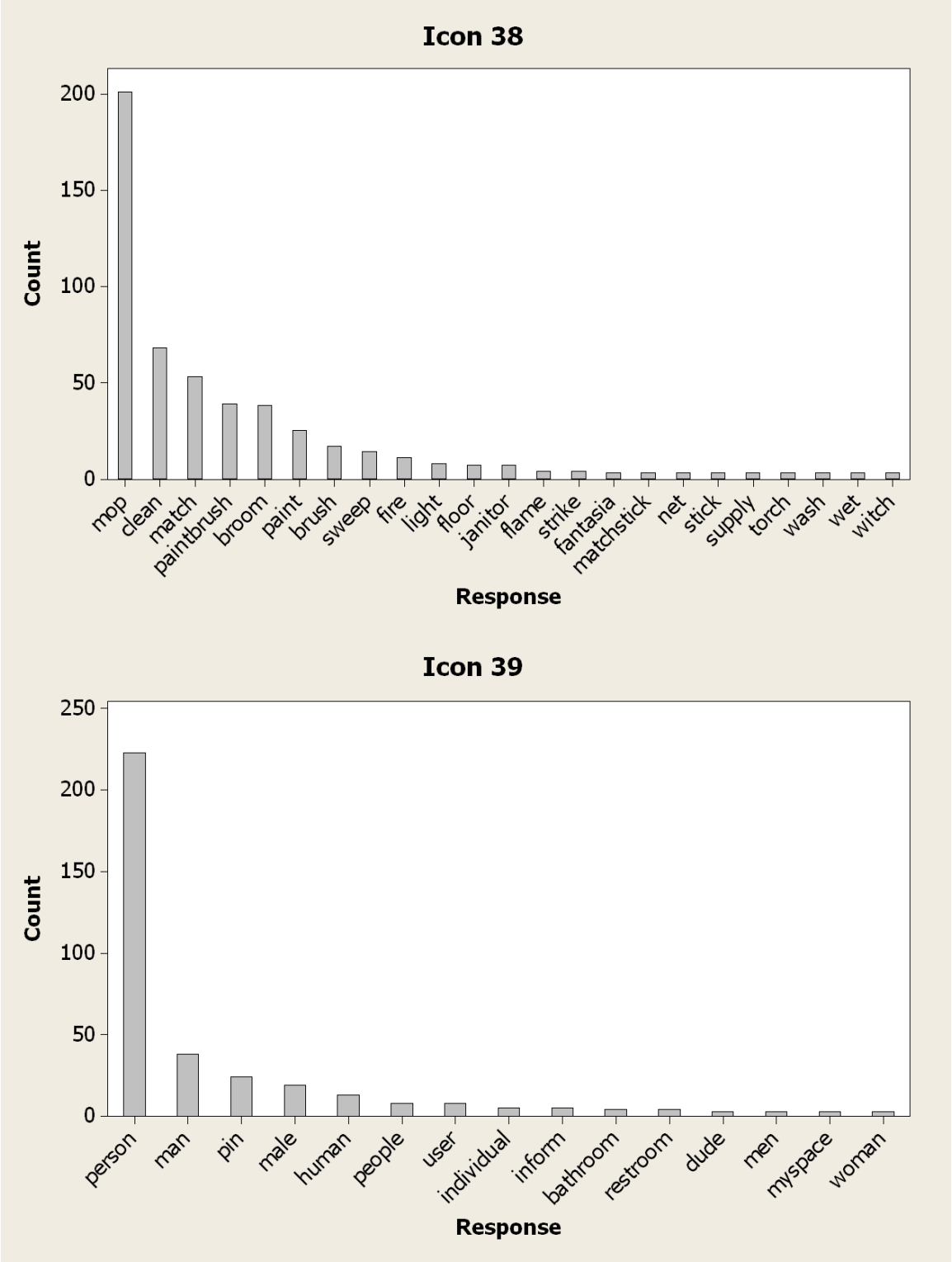

Icon 28
Count
250
200
150
100
50
0
mountain
crown
king
sharp
range
fire
peak
spikes
graph
terrain
danger
burger king
hill
jagged
point
Response
Icon 29
Count
100
80
60
40
20
0
eye
cbs
beachball
ball
sphere
basketball
circle
logo
bowl
globe
lock
nbc
o
watch
zero
beach
marble
moon
oval
blind
blink
disc
earth
eyeball
eyelid
mouth
open
planet
television
volleyball
Response

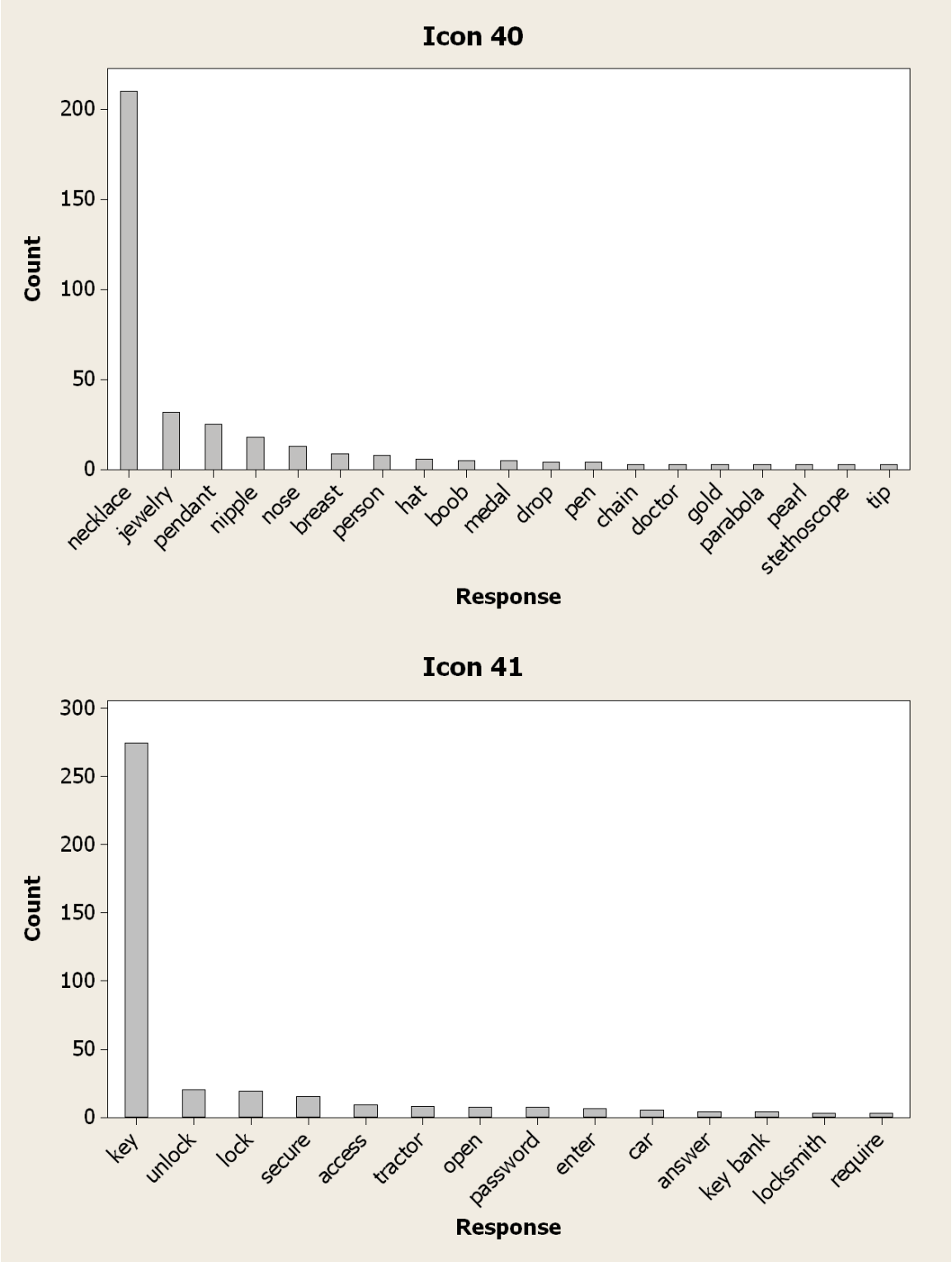

Icon 30
Count
300
250
200
150
100
50
0
bridge
tent
circus
connect
carnival
pier
cisco
powerline
water
line
san francisco
wire
boardwalk
cross
network
Response
Icon 31
Count
250
200
150
100
50
0
kite
diamond
cross
shield
gem
crystal
window
triangle
fly
church
pyramid
christ
christian
jewel
rhombus
wind
Response

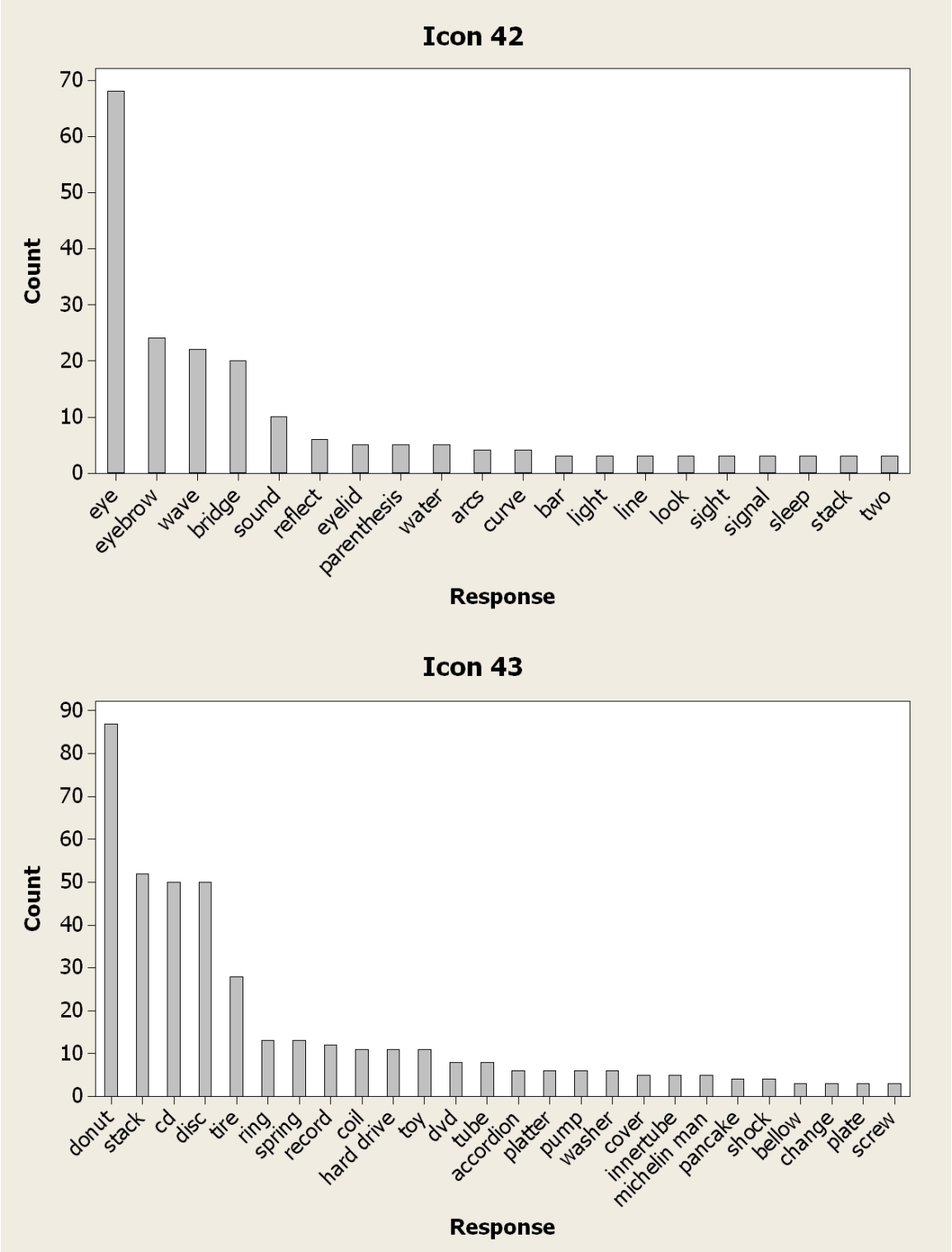

Icon 32
Count
0
10
20
30
40
50
60
70
80
90
diamond
gem
jewel
hexagon
window
honeycomb
emerald
crystal
glass
pentagon
facet
gemstone
octagon
stone
beehive
cube
design
geometry
ring
light
pattern
ruby
soccer
spiderweb
tie fighter
trapezoid
Response
Icon 33
Count
0
20
40
60
80
100
120
fan
cross
windmill
propeller
blade
religion
flower
radiate
radioactive
medal
nuclear
danger
fire department
church
hazard
military
pinwheel
badge
light
power
sun
umbrella
wind
alarm
award
blow
caution
chopper
emblem
firefighter
fireman
pin
safety
toxic
warn
Response

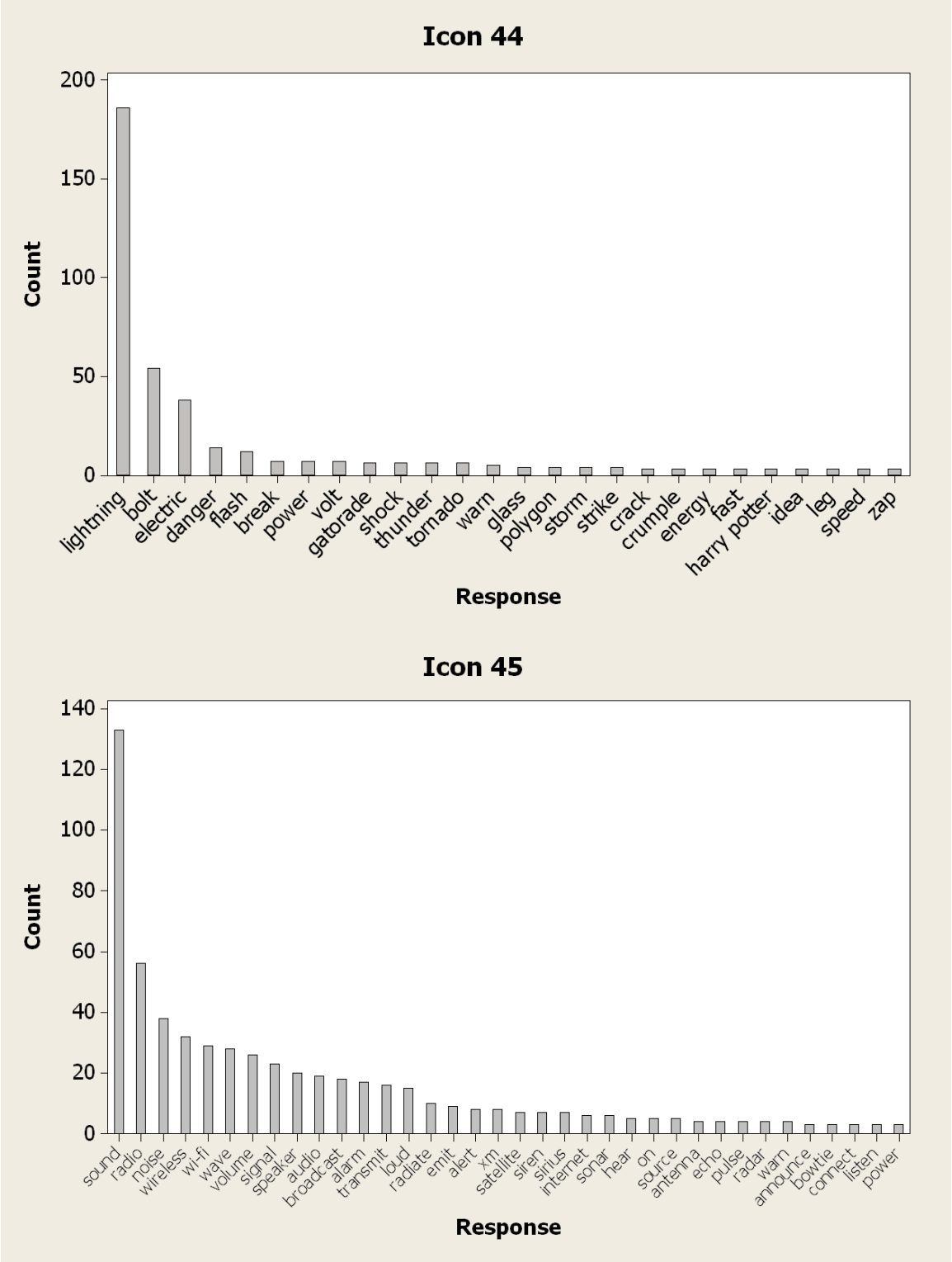

Icon 34
Count
200
150
100
50
0
uturn
turn
go
reverse
arrow
return
back
curve
sign
undo
direct
way
corner
left
loop
start
allow
around
button
change
redo
rewind
right
turnaround
Response
Icon 35
Count
200
150
100
50
0
lock
purse
bag
secure
handbag
padlock
shop
protect
safe
luggage
briefcase
suitcase
Response

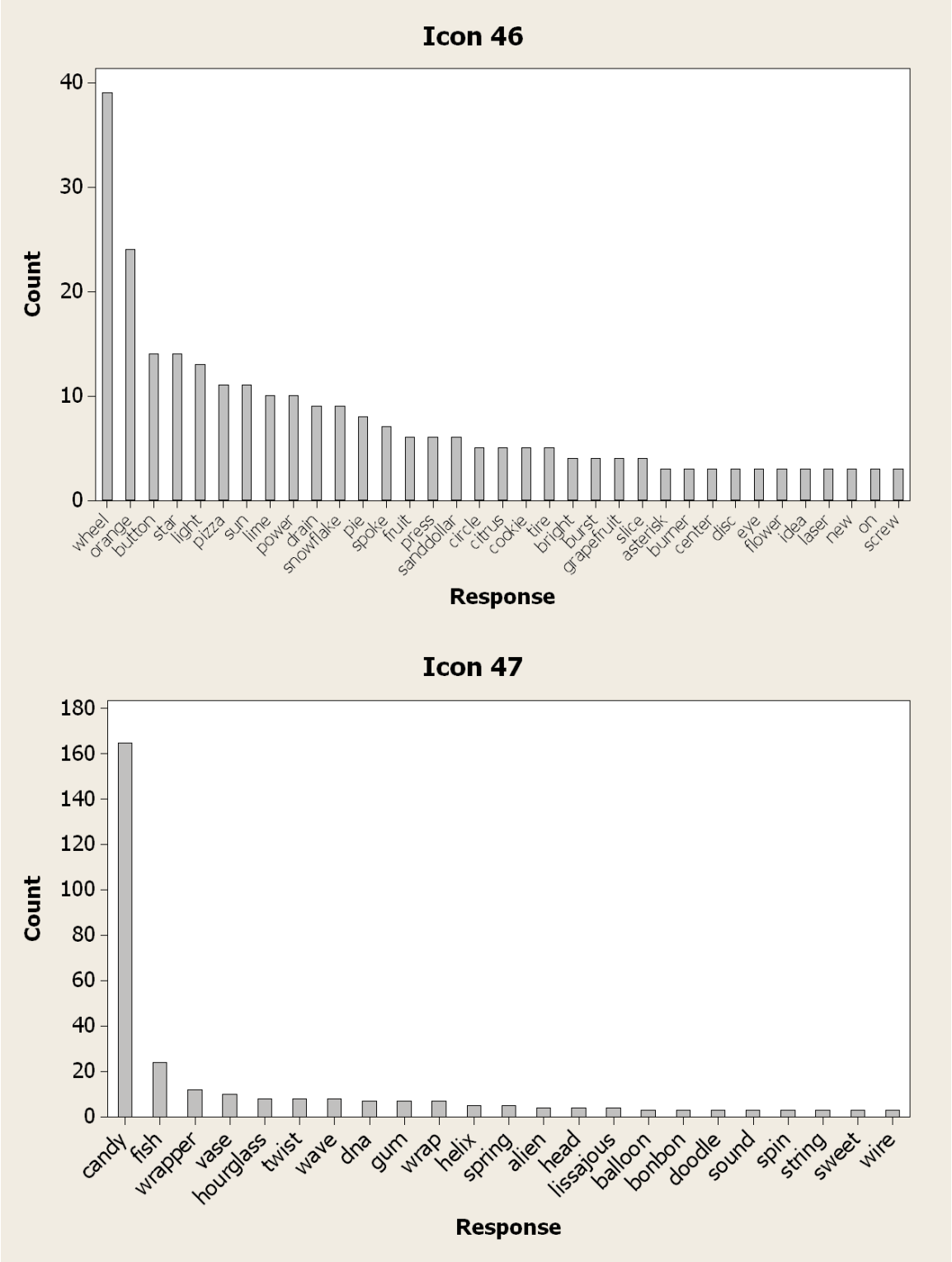

Icon 36
Count
Response
speaker
light
sound
project
box
noise
loud
tv
camera
move
radio
television
movie
volume
audio
flashlight
headlight
emit
film
horn
source
speed
siren
stereo
video
alarm
car
come
flash
fly
go
hear
led
microwave
music
mute
on
shout
speak
spotlight
talk
unmute
Icon 37
Count
Response
bandage
car
eraser
switch
first aid
mirror
eye
center
pill
buckle
bar
belt
level
light
middle
police
seatbelt
domino
slide
square
sushi
battery
box
button

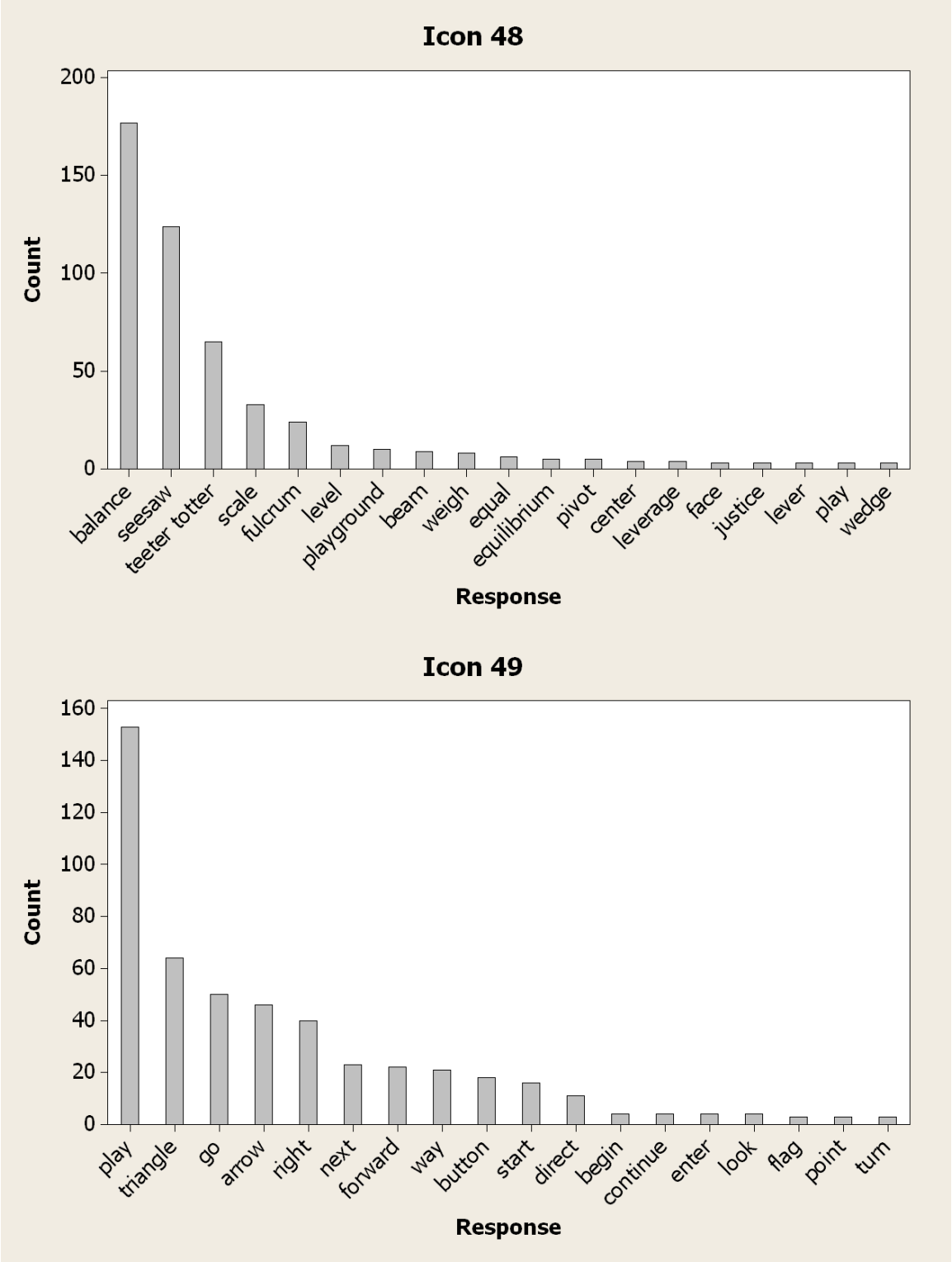

Icon 38
Count
200
150
100
50
0
mop
clean
match
paintbrush
broom
paint
brush
sweep
fire
light
floor
janitor
flame
strike
fantasia
matchstick
net
stick
supply
torch
wash
wet
witch
Response
Icon 39
Count
250
200
150
100
50
0
person
man
pin
male
human
people
user
individual
inform
bathroom
restroom
dude
men
myspace
woman
Response


Icon 40
Count
200
150
100
50
0
necklace
jewelry
pendant
nipple
nose
breast
person
hat
boob
medal
drop
pen
chain
doctor
gold
parabola
pearl
stethoscope
tip
Response
Icon 41
Count
300
250
200
150
100
50
0
key
unlock
lock
secure
access
tractor
open
password
enter
car
answer
key bank
locksmith
require
Response


Icon 42
Count
0
10
20
30
40
50
60
70
eye
eyebrow
wave
bridge
sound
reflect
eyelid
parenthesis
water
arcs
curve
bar
light
line
look
sight
signal
sleep
stack
two
Response
Icon 43
Count
0
10
20
30
40
50
60
70
80
90
donut
stack
cd
disc
tire
ring
spring
record
coil
hard drive
toy
dvd
tube
accordion
platter
pump
washer
cover
innertube
michelin man
pancake
shock
bellow
change
plate
screw
Response


Icon 44
Count
Response
lightning
bolt
electric
danger
flash
break
power
volt
gatorade
shock
thunder
tornado
warn
glass
polygon
storm
strike
crack
crumple
energy
fast
harry potter
idea
leg
speed
zap
Icon 45
Count
Response
sound
radio
noise
wireless
wi-fi
wave
volume
signal
speaker
audio
broadcast
alarm
transmit
loud
radiate
emit
alert
xm
satellite
siren
sirius
internet
sonar
hear
on
source
antenna
echo
pulse
radar
warn
announce
bowtie
connect
listen
power


Icon 46
Count
0
10
20
30
40
wheel
orange
button
star
light
pizza
sun
lime
power
drain
snowflake
pie
spoke
fruit
press
sanddollar
circle
citrus
cookie
tire
bright
burst
grapefruit
slice
asterisk
burner
center
disc
eye
flower
idea
laser
new
on
screw
Response
Icon 47
Count
0
20
40
60
80
100
120
140
160
180
candy
fish
wrapper
vase
hourglass
twist
wave
dna
gum
wrap
helix
spring
alien
head
lissajous
balloon
bonbon
doodle
sound
spin
string
sweet
wire
Response


Icon 48
Count
200
150
100
50
0
balance
seesaw
teeter totter
scale
fulcrum
level
playground
beam
weigh
equal
equilibrium
pivot
center
leverage
face
justice
lever
play
wedge
Response
Icon 49
Count
160
140
120
100
80
60
40
20
0
play
triangle
go
arrow
right
next
forward
way
button
start
direct
begin
continue
enter
look
flag
point
turn
Response

SAS Code

Running the following code in SAS will generate the data necessary for analysis. The code in this example is for icon #00. To run the code properly, one must insert the proper data for the analysis (every response that occurs 10 or more times) and change the base term (in this case, “bottle”) to the appropriate term. Changing the sort variable (in this case, country) is necessary to generate the appropriate statistics for a certain case.

```
proc format;
VALUE COLOR 1 = 'BLACK'
             2 = 'RED'
                  3 = 'GREEN
                  4 = 'BLUE
                  5 = 'ORANGE'
RUN;
data icon00;
input AGE$ GENDER$ TECHNICAL COUNTRY$ ICON COLOR RESP$;
CARDS;
31to45      male  1     usa   0     4     bomb
18to30      male  3     usa   0     3     bomb
31to45      male  2     usa   0     5     bomb
      ...
      <Include all data here>
      ...
18to30      male  1     usa   0     5     timer
46to60      female      2     usa   0     3     timer
18to30      male  3     dominican 0 2     timer
;
RUN;
PROC PRINT; RUN;

DATA ICON001;
SET ICON00;
IF COLOR=1 THEN COLORLAB='BLACK';
IF COLOR=2 THEN COLORLAB='RED';
IF COLOR=3 THEN COLORLAB='GREEN';
IF COLOR=4 THEN COLORLAB='BLUE';
IF COLOR=5 THEN COLORLAB='ORANGE';
IF RESP='bomb' THEN RESPSORT = 'yes';
ELSE RESPSORT = 'no';
RUN;

proc sort data=ICON001;
by  DESCENDING COLORLAB;
run;

proc sort data=ICON001;
by  COUNTRY;
run;

proc sort data=ICON001;
by  RESPSORT;
run;
```

```
PROC FREQ DATA=ICON001;
TABLES AGE*GENDER*TECHNICAL*COUNTRY*COLORLAB*RESP/ out=FreqCount ;
run;

proc catmod data=ICON001 order=data;
direct technical;
model resp = COLORLAB gender technical age country /FREQ;
contrast "Black vs. Colors" COLORLAB 1 -0.333334 -0.333333 -0.333333;
run;
quit;
```

Data Analysis

Listed below is the analysis for all corresponding data for each of the selected icons. The "category" column describes which characteristic is described. The "variable" describes the specific attribute in each category. The "fnum" column relates to the specific response noted in the list. The "est", or estimate, column describes the linear coefficient. The "stdev" is the standard deviation, "oddratio" is the odds ratio, and "p" is the calculated p value for the data set.

Icon 00

Category	Variable	Response	Est	Std Err	Odd Ratio	P
Color	RED	grenade	0.5126	0.4175	1.66962659	0.2195
Color	RED	bottle	-1.2301	0.8639	0.29226335	0.1545
Color	RED	ornament	-0.4781	0.588	0.6199602	0.4162
Color	RED	timer	-0.9098	0.7214	0.40260474	0.2073
Color	RED	perfume	0.1204	0.6181	1.12794794	0.8455
Color	RED	stopwatc	-0.0835	0.348	0.91989109	0.8104
Color	RED	canteen	0.2127	0.4101	1.23701349	0.604
Color	RED	clock	-0.7347	0.8779	0.47964933	0.4026
Color	RED	flask	-0.4553	0.6699	0.63425766	0.4967
Color	RED	tank	0.4376	0.5334	1.54898519	0.4119
Color	RED	time	0.3225	0.5484	1.38057489	0.5565
Color	ORANG	grenade	-0.3897	0.5488	0.67726002	0.4777
Color	ORANG	bottle	-0.4569	0.731	0.63324366	0.532
Color	ORANG	ornament	1.1158	0.5348	3.05200881	0.0369
Color	ORANG	timer	0.658	0.5527	1.93092662	0.2338
Color	ORANG	perfume	-0.7019	0.9367	0.49564269	0.4536
Color	ORANG	stopwatc	0.0796	0.3377	1.08285384	0.8136
Color	ORANG	canteen	0.2345	0.4116	1.26427647	0.5688
Color	ORANG	clock	0.8618	0.5344	2.36741821	0.1069
Color	ORANG	flask	-0.7308	0.8682	0.48152362	0.3999
Color	ORANG	tank	0.0814	0.6984	1.08480473	0.9073

Color	ORANG	time	0.5676	0.554	1.7640283	0.3056
Color	GREEN	grenade	-1.1023	0.6442	0.33210636	0.0871
Color	GREEN	bottle	0.3711	0.5115	1.449328	0.4682
Color	GREEN	ornament	0.3741	0.5276	1.45368251	0.4783
Color	GREEN	timer	0.6507	0.5162	1.91688218	0.2075
Color	GREEN	perfume	0.1047	0.6155	1.11037745	0.8649
Color	GREEN	stopwatc	-0.0438	0.3239	0.95714537	0.8925
Color	GREEN	canteen	-0.07	0.4156	0.93239382	0.8663
Color	GREEN	clock	-0.8558	0.8686	0.4249431	0.3245
Color	GREEN	flask	-0.4584	0.6645	0.63229451	0.4902
Color	GREEN	tank	0.0126	0.5968	1.01267971	0.9832
Color	GREEN	time	-0.9934	0.86	0.37031548	0.248
Color	BLUE	grenade	0.4705	0.4332	1.60079439	0.2775
Color	BLUE	bottle	1.0245	0.4899	2.78570226	0.0365
Color	BLUE	ornament	-1.0098	0.91	0.36429183	0.2672
Color	BLUE	timer	-0.7242	0.8648	0.48471218	0.4023
Color	BLUE	perfume	0.9009	0.5831	2.46181775	0.1224
Color	BLUE	stopwatc	-0.0276	0.348	0.9727774	0.9367
Color	BLUE	canteen	-0.1909	0.4549	0.82621521	0.6748
Color	BLUE	clock	0.5442	0.5661	1.72322925	0.3364
Color	BLUE	flask	1.1548	0.4823	3.17338868	0.0167
Color	BLUE	tank	0.00136	0.6976	1.00136093	0.9984
Color	BLUE	time	-0.7096	0.7027	0.49184089	0.3126
Gender	female	grenade	-0.421	0.2739	0.6563901	0.1243
Gender	female	bottle	-0.00975	0.2922	0.99029738	0.9734
Gender	female	ornament	0.7375	0.3573	2.09070222	0.039
Gender	female	timer	-0.4996	0.371	0.60677332	0.1781
Gender	female	perfume	0.3007	0.3501	1.35080404	0.3904
Gender	female	stopwatc	-0.3729	0.1983	0.6887341	0.06
Gender	female	canteen	-0.4768	0.2551	0.62076667	0.0616
Gender	female	clock	-0.5104	0.3768	0.60025543	0.1755
Gender	female	flask	-0.3593	0.3193	0.69816487	0.2606
Gender	female	tank	0.011	0.3335	1.01106072	0.9737
Gender	female	time	-0.8187	0.3493	0.44100459	0.0191
Tech Exp	N/A	grenade	-0.0133	0.1802	0.98678805	0.9412
Tech Exp	N/A	bottle	0.1296	0.2145	1.13837294	0.5459
Tech Exp	N/A	ornament	0.3745	0.2036	1.4542641	0.0658
Tech Exp	N/A	timer	-0.1484	0.288	0.86208621	0.6064
Tech Exp	N/A	perfume	-0.1583	0.2895	0.85359367	0.5844
Tech Exp	N/A	stopwatc	-0.00489	0.1438	0.99512194	0.9729
Tech Exp	N/A	canteen	0.0948	0.1708	1.09943895	0.5787

Tech Exp	N/A	clock	0.1323	0.2303	1.1414507	0.5656
Tech Exp	N/A	flask	0.1807	0.195	1.19805571	0.3542
Tech Exp	N/A	tank	-0.0256	0.2707	0.9747249	0.9245
Tech Exp	N/A	time	0.474	0.1994	1.60640699	0.0174
Age	61over	time	3.7316	1.0184	41.7458482	0.0002
Age	61over	ornament	1.2527	1.1983	3.49977962	0.2959
Age	61over	stopwatc	0.9737	0.9447	2.64772293	0.3027
Age	61over	tank	1.3778	1.1136	3.96616646	0.216
Age	61over	canteen	0.9511	1.0959	2.58855551	0.3855
Age	61over	flask	-3.9686	.	0.01889987	.
Age	61over	grenade	-4.0745	.	0.01700071	.
Age	61over	perfume	-3.5541	.	0.02860711	.
Age	61over	bottle	-3.9005	.	0.02023179	.
Age	61over	timer	-3.6712	.	0.02544592	.
Age	61over	clock	-2.654	.	0.07036917	.
Age	46to60	time	-7.1738	.	0.0007664	.
Age	46to60	ornament	0.7058	0.5945	2.02546641	0.2351
Age	46to60	stopwatc	-0.4323	0.5236	0.64901464	0.409
Age	46to60	tank	0.5246	0.585	1.6897828	0.3698
Age	46to60	canteen	-0.3074	0.6276	0.7353564	0.6242
Age	46to60	flask	2.1954	0.4487	8.98359379	<.0001
Age	46to60	grenade	1.3554	0.4956	3.87831197	0.0062
Age	46to60	perfume	1.43	0.578	4.1786992	0.0134
Age	46to60	bottle	1.6455	0.4846	5.18360106	0.0007
Age	46to60	timer	1.2912	0.571	3.63714852	0.0237
Age	46to60	clock	-4.3598	.	0.01278094	.
Age	31to45	time	2.1009	0.6333	8.17352278	0.0009
Age	31to45	ornament	-0.5227	0.622	0.59291751	0.4008
Age	31to45	stopwatc	-0.2501	0.4617	0.77872291	0.588
Age	31to45	tank	-0.1299	0.5926	0.87818324	0.8265
Age	31to45	canteen	-0.4127	0.5785	0.66186081	0.4755
Age	31to45	flask	1.1305	0.4802	3.09720472	0.0186
Age	31to45	grenade	1.2728	0.4456	3.57083692	0.0043
Age	31to45	perfume	1.8	0.4641	6.04964747	0.0001
Age	31to45	bottle	1.9179	0.4001	6.80664949	<.0001
Age	31to45	timer	1.692	0.4777	5.43033052	0.0004
Age	31to45	clock	3.4845	0.4134	32.60612	<.0001
Country	canada	grenade	3.0057	0.8141	20.2003514	0.0002
Country	canada	bottle	-8.801	.	0.00015058	.
Country	canada	ornament	-5.8791	.	0.0027973	.
Country	canada	timer	-4.3894	.	0.01240817	.

Country	canada	perfume	-5.809	.	0.00300043	.
Country	canada	stopwatc	-5.4098	.	0.00447253	.
Country	canada	canteen	-3.8846	.	0.02055605	.
Country	canada	clock	-2.6471	.	0.0708564	.
Country	canada	flask	-3.3687	.	0.03443437	.
Country	canada	tank	-4.4903	.	0.01121728	.
Country	canada	time	-2.7686	.	0.06274979	.
Country	dominica	grenade	-2.7999	.	0.06081614	.
Country	dominica	bottle	1.0002	1.1804	2.71882554	0.3968
Country	dominica	ornament	5.0377	.	154.115143	.
Country	dominica	timer	3.8463	.	46.8195103	.
Country	dominica	perfume	2.6937	.	14.7862841	.
Country	dominica	stopwatc	-3.0693	.	0.04645366	.
Country	dominica	canteen	-2.7542	.	0.06365993	.
Country	dominica	clock	-2.9043	.	0.05478713	.
Country	dominica	flask	-2.9552	.	0.05206825	.
Country	dominica	tank	-2.5642	.	0.07698074	.
Country	dominica	time	-2.7769	.	0.06223113	.
Country	india	grenade	-3.4764	.	0.03091852	.
Country	india	bottle	-0.098	0.894	0.9066489	0.9127
Country	india	ornament	-3.0564	.	0.0470568	.
Country	india	timer	-2.7309	.	0.06516062	.
Country	india	perfume	4.834	.	125.712808	.
Country	india	stopwatc	3.909	.	49.8490781	.
Country	india	canteen	-4.9199	.	0.00729986	.
Country	india	clock	-3.192	.	0.04108961	.
Country	india	flask	-4.5065	.	0.01103702	.
Country	india	tank	-3.7286	.	0.02402645	.
Country	india	time	-5.1888	.	0.0055787	.
Country	kazakhst	grenade	2.6277	.	13.8418969	.
Country	kazakhst	bottle	10.8611	.	52109.3673	.
Country	kazakhst	ornament	2.8739	1.5709	17.7059369	0.0673
Country	kazakhst	timer	2.6676	.	14.4053548	.
Country	kazakhst	perfume	-4.2223	1.3873	0.01466488	0.0023
Country	kazakhst	stopwatc	0.8297	1.2597	2.29263085	0.5101
Country	kazakhst	canteen	4.6224	.	101.737911	.
Country	kazakhst	clock	3.9771	.	53.3620598	.
Country	kazakhst	flask	3.5221	.	33.8554504	.
Country	kazakhst	tank	3.5858	.	36.082212	.
Country	kazakhst	time	3.2845	.	26.6956332	.

Icon 16

Category	Variable	Response	Est	Std Err	Odd Ratio	P
Color	RED	chart	0.6101	0.8461	1.840615	0.4708
Color	RED	circle	3.0996	0.8173	22.18907	0.0001
Color	RED	cut	1.8636	0.7032	6.446904	0.008
Color	RED	open	0.6498	0.8014	1.915158	0.4175
Color	RED	pie	0.9886	0.6895	2.687469	0.1516
Color	RED	slice	2.8133	0.723	16.66482	<.0001
Color	RED	wedge	2.6202	.	13.73847	.
Color	ORANG	chart	-0.4958	0.7833	0.609083	0.5267
Color	ORANG	circle	1.5906	0.7893	4.906692	0.0439
Color	ORANG	cut	-0.7984	0.7705	0.450048	0.3001
Color	ORANG	open	-1.6855	0.9655	0.185352	0.0809
Color	ORANG	pie	-0.342	0.6827	0.710348	0.6164
Color	ORANG	slice	0.7404	0.7631	2.096774	0.332
Color	ORANG	wedge	1.4494	1.0193	4.260557	0.155
Color	GREEN	chart	0.3167	0.7797	1.372591	0.6847
Color	GREEN	circle	0.5939	1.0684	1.811038	0.5783
Color	GREEN	cut	-0.2655	0.9776	0.766822	0.786
Color	GREEN	open	0.4027	0.8111	1.495858	0.6196
Color	GREEN	pie	-1.0004	0.9732	0.367732	0.304
Color	GREEN	slice	-7.6947	.	0.000455	.
Color	GREEN	wedge	2.5848	.	13.26064	.
Color	BLUE	chart	1.1289	0.9499	3.092253	0.2347
Color	BLUE	circle	-4.7365	.	0.008769	.
Color	BLUE	cut	-0.2744	1.196	0.760028	0.8185
Color	BLUE	open	1.2989	0.9735	3.665263	0.1821
Color	BLUE	pie	0.7215	0.908	2.057517	0.4268
Color	BLUE	slice	3.9773	1.0998	53.37273	0.0003
Color	BLUE	wedge	1.559	1.5544	4.754065	0.3159
Gender	female	circle	0.4594	0.5791	1.583124	0.4276
Gender	female	chart	0.3395	0.4926	1.404245	0.4907
Gender	female	cut	0.0585	0.536	1.060245	0.9131
Gender	female	wedge	-0.341	0.6715	0.711059	0.6116
Gender	female	pie	0.6162	0.5095	1.851878	0.2265
Gender	female	slice	2.2466	0.9071	9.455532	0.0133
Gender	female	open	0.1267	0.5147	1.135076	0.8055
Technical	N/A	circle	0.1109	0.346	1.117283	0.7486
Technical	N/A	chart	0.201	0.3041	1.222625	0.5085
Technical	N/A	cut	-0.2363	0.3341	0.789544	0.4793
Technical	N/A	wedge	-0.3458	0.3897	0.707654	0.3748

Technical	N/A	pie	-0.3009	0.342	0.740152	0.379
Technical	N/A	slice	-1.6155	0.7796	0.198791	0.0383
Technical	N/A	open	0.028	0.3248	1.028396	0.9313
Age	61over	wedge	9.8104	.	18222.27	.
Age	61over	chart	-3.0655	.	0.046631	.
Age	61over	circle	2.5569	.	12.89578	.
Age	61over	open	-2.8982	.	0.055122	.
Age	61over	cut	-2.8424	.	0.058286	.
Age	61over	slice	-3.0332	.	0.048161	.
Age	61over	pie	-3.0448	.	0.047606	.
Age	46to60	wedge	0.0398	4.8346	1.040603	0.9934
Age	46to60	chart	2.0667	0.8881	7.898714	0.02
Age	46to60	circle	0.5225	0.9584	1.686238	0.5857
Age	46to60	open	1.6184	0.8034	5.045012	0.044
Age	46to60	cut	1.9267	0.8043	6.866812	0.0166
Age	46to60	slice	-1.3172	1.9576	0.267884	0.501
Age	46to60	pie	-2.597	.	0.074497	.
Age	31to45	wedge	-7.7361	9.5739	0.000437	0.4191
Age	31to45	chart	0.2361	0.9221	1.266301	0.7979
Age	31to45	circle	-2.1196	0.9488	0.12008	0.0255
Age	31to45	open	1.4912	0.6918	4.442423	0.0311
Age	31to45	cut	0.4687	0.7402	1.597916	0.5266
Age	31to45	slice	1.8065	1.104	6.089098	0.1018
Age	31to45	pie	-2.5884	.	0.07514	.
Country	canada	circle	2.5067	.	12.26439	.
Country	canada	chart	4.6909	.	108.9512	.
Country	canada	cut	-3.1997	.	0.040774	.
Country	canada	wedge	-0.7703	1.515	0.462874	0.6112
Country	canada	pie	-2.5008	.	0.082019	.
Country	canada	slice	-2.5167	.	0.080726	.
Country	canada	open	-3.3302	.	0.035786	.
Country	china	circle	6.7986	.	896.5912	.
Country	china	chart	-1.5976	4.6116	0.202382	0.729
Country	china	cut	-0.7907	1.5957	0.453527	0.6202
Country	china	wedge	-2.525	.	0.080058	.
Country	china	pie	-2.7868	.	0.061618	.
Country	china	slice	-2.6711	.	0.069176	.
Country	china	open	-2.9972	.	0.049927	.
Country	india	circle	-6.7454	4.611	0.001176	0.1435
Country	india	chart	-3.4884	.	0.03055	.
Country	india	cut	2.9138	.	18.42669	.

Country	india	wedge	2.5847	.	13.25931	.
Country	india	pie	2.5699	.	13.06452	.
Country	india	slice	1.7101	0.9733	5.529514	0.0789
Country	india	open	-2.6365	.	0.071611	.

Icon 25

Category	Variable	Response	Est	Std Err	Odd Ratio	P
Color	RED	female	1.6467	0.584	5.189825	0.0048
Color	RED	person	0.5262	0.4108	1.692489	0.2002
Color	RED	sign	0.0666	0.4025	1.068868	0.8686
Color	RED	tree	0.0438	0.3781	1.044773	0.9077
Color	RED	magnifyi	0.0252	0.4115	1.02552	0.9512
Color	RED	key	-0.35	0.6448	0.704406	0.5868
Color	RED	search	-0.071	0.6945	0.931928	0.9192
Color	RED	magnify	-0.912	0.8635	0.40168	0.2909
Color	RED	balloon	-1.055	0.8611	0.348332	0.2207
Color	RED	head	1.7003	0.6294	5.47559	0.0069
Color	BLUE	female	1.7201	0.5622	5.585087	0.0022
Color	BLUE	person	0.2328	0.4317	1.262129	0.5896
Color	BLUE	sign	-0.559	0.49	0.572009	0.2542
Color	BLUE	tree	0.6046	0.3259	1.83052	0.0636
Color	BLUE	magnifyi	-0.329	0.4877	0.719715	0.5001
Color	BLUE	key	0.073	0.5187	1.075731	0.8881
Color	BLUE	search	-0.517	0.8879	0.596545	0.5607
Color	BLUE	magnify	0.1169	0.5869	1.124007	0.8422
Color	BLUE	balloon	0.5923	0.5106	1.808142	0.2461
Color	BLUE	head	-7.715	.	0.000446	.
Color	ORANG	female	1.672	0.6392	5.322803	0.0089
Color	ORANG	person	0.0913	0.472	1.095598	0.8465
Color	ORANG	sign	0.3239	0.4054	1.382509	0.4243
Color	ORANG	tree	0.0068	0.3947	1.006813	0.9863
Color	ORANG	magnifyi	-0.065	0.4528	0.937255	0.8861
Color	ORANG	key	-0.568	0.6464	0.566601	0.3795
Color	ORANG	search	0.3044	0.6143	1.355811	0.6203
Color	ORANG	magnify	0.4194	0.5926	1.521049	0.4791
Color	ORANG	balloon	-0.118	0.6663	0.888785	0.8595
Color	ORANG	head	1.4588	0.642	4.300795	0.0231
Color	GREEN	female	-6.806	.	0.001107	.
Color	GREEN	person	-1.211	0.8431	0.297929	0.1509
Color	GREEN	sign	0.168	0.4525	1.182937	0.7104
Color	GREEN	tree	-0.265	0.4452	0.767359	0.552

Color	GREEN	magnifyi	0.5303	0.4062	1.699442	0.1917
Color	GREEN	key	0.4084	0.5063	1.504409	0.4198
Color	GREEN	search	0.528	0.6457	1.695538	0.4135
Color	GREEN	magnify	0.5519	0.5989	1.736549	0.3568
Color	GREEN	balloon	0.1643	0.5879	1.178568	0.7799
Color	GREEN	head	2.0885	0.5673	8.072797	0.0002
Gender	female	female	-0.462	0.4024	0.62977	0.2506
Gender	female	person	0.3766	0.2391	1.457321	0.1153
Gender	female	sign	-0.006	0.2325	0.994018	0.9794
Gender	female	tree	-0.151	0.2169	0.860192	0.4875
Gender	female	magnifyi	0.0242	0.2327	1.024495	0.9173
Gender	female	key	-0.377	0.3704	0.686122	0.3091
Gender	female	search	0.1902	0.3794	1.209491	0.6162
Gender	female	magnify	0.163	0.3446	1.177037	0.6363
Gender	female	balloon	-0.577	0.3433	0.561524	0.0927
Gender	female	head	-0.388	0.4348	0.678209	0.3719
Tech Exp	N/A	magnifyi	0.2156	0.167	1.240606	0.1965
Tech Exp	N/A	tree	-0.01	0.1627	0.990129	0.9514
Tech Exp	N/A	balloon	0.3589	0.2055	1.431754	0.0808
Tech Exp	N/A	magnify	0.0035	0.2563	1.003496	0.9891
Tech Exp	N/A	head	-0.368	0.3535	0.69191	0.2975
Tech Exp	N/A	person	-0.127	0.193	0.880558	0.5097
Tech Exp	N/A	search	-0.506	0.385	0.603144	0.1891
Tech Exp	N/A	sign	0.3174	0.1612	1.373552	0.0489
Tech Exp	N/A	female	0.2423	0.2693	1.274176	0.3682
Tech Exp	N/A	key	-0.309	0.2806	0.734254	0.271
Age	61over	magnifyi	1.1754	0.6772	3.239438	0.0826
Age	61over	tree	0.2244	0.9038	1.251572	0.804
Age	61over	balloon	0.6217	0.9464	1.862091	0.5112
Age	61over	magnify	1.0874	0.9517	2.966551	0.2532
Age	61over	head	-4.687	.	0.009216	.
Age	61over	person	-5.469	.	0.004217	.
Age	61over	search	-3.878	.	0.020703	.
Age	61over	sign	-5.624	.	0.003611	.
Age	61over	female	-3.854	.	0.021205	.
Age	61over	key	-4.39	.	0.012396	.
Age	46to60	magnifyi	0.6145	0.4087	1.848732	0.1326
Age	46to60	tree	-0.457	0.5414	0.633497	0.3991
Age	46to60	balloon	-0.02	0.6783	0.980591	0.977
Age	46to60	magnify	-0.882	0.8572	0.413913	0.3035
Age	46to60	head	1.2101	0.7864	3.35382	0.1238

Age	46to60	person	1.2576	0.464	3.516971	0.0067
Age	46to60	search	1.8198	0.581	6.170624	0.0017
Age	46to60	sign	2.1763	0.3537	8.813635	<.0001
Age	46to60	female	0.5598	0.8127	1.750322	0.491
Age	46to60	key	0.9525	0.7479	2.592182	0.2028
Age	31to45	magnifyi	-0.989	0.5246	0.371837	0.0593
Age	31to45	tree	0.2015	0.4448	1.223236	0.6505
Age	31to45	balloon	-0.334	0.6711	0.715911	0.6185
Age	31to45	magnify	0.2616	0.5743	1.299007	0.6487
Age	31to45	head	1.1818	0.7822	3.260237	0.1308
Age	31to45	person	2.2036	0.3584	9.057562	<.0001
Age	31to45	search	0.676	0.7334	1.965998	0.3566
Age	31to45	sign	1.9467	0.3445	7.005531	<.0001
Age	31to45	female	1.9679	0.6063	7.155634	0.0012
Age	31to45	key	1.3698	0.6143	3.934564	0.0258

Icon 46

Category	Variable	Response	Est	Std Err	Odd Ratio	P
Color	RED	pizza	0.5649	0.6419	1.759272	0.3789
Color	RED	button	0.4514	0.6123	1.570509	0.461
Color	RED	star	0.001	0.6197	1.001001	0.9987
Color	RED	lime	-3.505	.	0.030041	.
Color	RED	sun	0.6327	0.8655	1.882687	0.4648
Color	RED	orange	-1.084	0.7227	0.33824	0.1336
Color	RED	light	-0.789	0.7082	0.454526	0.2655
Color	RED	power	1.0616	0.7822	2.890993	0.1747
Color	ORANG	pizza	0.052	0.7761	1.053376	0.9466
Color	ORANG	button	-0.774	0.9286	0.461026	0.4043
Color	ORANG	star	-1.05	0.9432	0.349903	0.2656
Color	ORANG	lime	-2.949	.	0.052382	.
Color	ORANG	sun	2.5317	0.6314	12.57487	<.0001
Color	ORANG	orange	1.4054	0.5616	4.077157	0.0123
Color	ORANG	light	0.6972	0.6308	2.008122	0.2691
Color	ORANG	power	-8.37	.	0.000232	.
Color	GREEN	pizza	0.6012	0.8477	1.824307	0.4782
Color	GREEN	button	0.4922	0.7351	1.635911	0.5032
Color	GREEN	star	0.5859	0.7326	1.796607	0.4238
Color	GREEN	lime	-2.991	.	0.050222	.
Color	GREEN	sun	-6.807	.	0.001106	.
Color	GREEN	orange	0.1476	0.7951	1.159049	0.8528
Color	GREEN	light	0.4031	0.6775	1.496457	0.5519

Color	GREEN	power	3.316	0.9247	27.54993	0.0003
Color	BLUE	pizza	-0.404	0.9545	0.667711	0.6722
Color	BLUE	button	0.2139	0.7536	1.238499	0.7765
Color	BLUE	star	0.8568	0.6449	2.355611	0.184
Color	BLUE	lime	5.8156	0.5398	335.4926	<.0001
Color	BLUE	sun	2.0021	0.7319	7.404589	0.0062
Color	BLUE	orange	-0.748	0.9386	0.473218	0.4254
Color	BLUE	light	0.2339	0.7536	1.263518	0.7563
Color	BLUE	power	1.5486	0.9304	4.704879	0.096
Gender	female	button	0.1893	0.4309	1.208403	0.6604
Gender	female	orange	0.0079	0.3385	1.007941	0.9814
Gender	female	power	1.0483	0.6127	2.852797	0.0871
Gender	female	sun	-0.123	0.4315	0.884617	0.7762
Gender	female	light	-0.446	0.4043	0.639992	0.2696
Gender	female	pizza	0.1546	0.4692	1.167191	0.7418
Gender	female	star	0.536	0.4096	1.709157	0.1907
Gender	female	lime	-0.86	0.6576	0.423331	0.1911
Technical	N/A	button	-0.308	0.3098	0.734989	0.3203
Technical	N/A	orange	0.0603	0.2223	1.062155	0.7862
Technical	N/A	power	-1.123	0.5951	0.325433	0.0592
Technical	N/A	sun	0.1805	0.2805	1.197816	0.5198
Technical	N/A	light	0.1533	0.2368	1.165675	0.5174
Technical	N/A	pizza	-0.347	0.3313	0.706947	0.2953
Technical	N/A	star	-0.213	0.2819	0.807995	0.4496
Technical	N/A	lime	-0.108	0.3308	0.897807	0.7446

Appendix E – Communications, Documentation, and Forms

Screener

Thank you very much for agreeing to participate.

You will first need to share some personal information. This will help us analyze the results after we gather enough data. We will not disclose any of your responses in a way that will be associated with your identity.

Please acknowledge that this is a scientific study and should be treated as such. This experiment has been developed by a Master's student at the Rochester Institute of Technology. The data collected in this experiment will be used for completion of a Master's capstone thesis.

First Time:

Checkbox: To the best of my knowledge, this is my first time taking this survey.

Age Verification:

Checkbox: I certify that I am 18 years of age or older.

Age Range:

Radio Button: 18 to 30; 31 to 45; 46 to 60; Over 60

Gender:

Radio Button: Male; Female

Technical Experience:

Radio Button: (Lickert Scale 1-7) Very Experienced; Some Experience; No Experience

Country:

Dropdown Select: (List of all countries) Select the country where you have spent the majority of your life.

Email:

Text Input: You are not required to share your email address. You must share your email to be eligible to win the incentive prize. If you win, we will contact you through this address.

Consent Form:

Checkbox: I agree to the consent form and acknowledge that this is a scientific study and should be treated as such. Click here to read the Consent Form.

Are you colorblind?

Radio Button: No, I am not colorblind; Yes, I am in some way colorblind; I am not sure whether or not I am colorblind

Icon Survey

Enter a word or phrase in the box to the right that the image represents. Press "+" or the Enter key on your keyboard to add your response. You may write as many or as few answers as you wish. Press "Finish" or the Enter key twice quickly to see the next image.

Consent Form

The purpose of this investigation is to gain a better understanding of how people interpret graphic symbols so designers can develop clearer, more intuitive icons.

If you decide to participate in this icon interpretation study, you will be asked to complete a short screener survey. Next, you will be shown 50 icons. In the accompanying box, you will write what you believe the icon represents. The survey should take approximately 10 to 15 minutes.

All personal information will be kept confidential and no information that could identify you will appear in published reports. If you decide to provide your email, it will be kept private and never

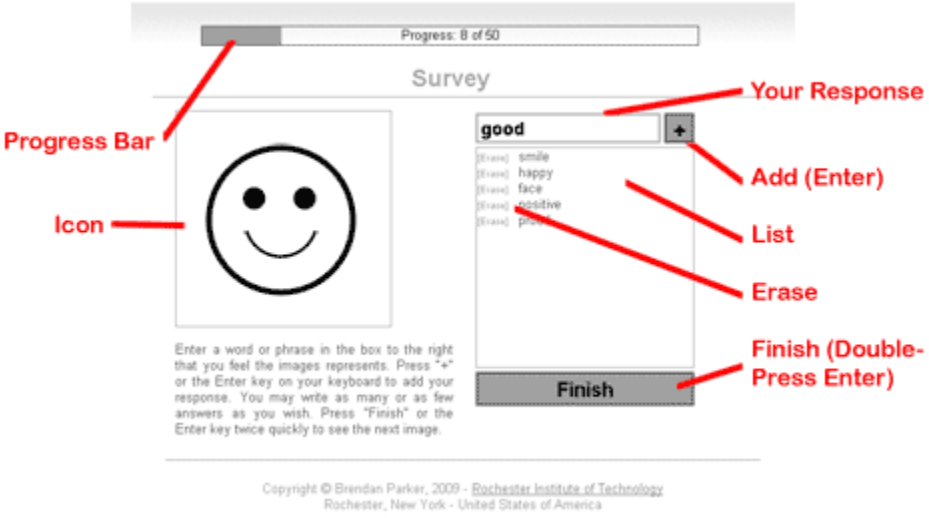
be published. When the study is complete and enough people have participated, we will analyze the data and publish the results.

This study has been approved by the Rochester Institute of Technology's Institutional Review Board to assure the quality, ethics, and safety of the experiment. We do not anticipate any risk to participants.

Participation is completely voluntary. You may withdraw from participating in the study at any time if you decide to quit in the middle of the survey by pressing the red Quit button in the upper right. Even if you quit, you will still be eligible to win the incentive if you have provided your email address. Please contact me at info@iconstudy.com if you have any questions or concerns.

Please remember that this is a scientific study and should be treated as such. Answer the questions as truthfully as you can.

Instructions



- When you start the survey, an icon will appear.
- On the right is a box in which you will write what you believe the icon represents. After you write a word or phrase in the box, click the "+" button or press the Enter (or Return) key on your keyboard. This will add your answer to your list.

- Your answer will show in the large response box. The response box lists all your answers. If you want to remove a submitted response, press the Erase button adjacent to the response to remove that response.
- You may submit as many responses as you would like. When you feel you have added enough, press the Finish button or press the Enter (or Return) key on your keyboard twice quickly.
- When you press finish, your responses will clear. New icons will appear until you have completed the study. The Progress Bar at the top of the screen shows how close you are to finishing the survey.
- You will need to fill out a short questionnaire beforehand so we know more about you. Click here to start the survey.

Appendix F – Instructional Review Board Approval

Performing this experiment at the Rochester Institute of Technology required approval from the Instructional Review Board, as it involved human subjects. The statement below is the signed approval form stating that this experiment involves no higher than minimal risk to the subjects.

R·I·T

Rochester Institute of Technology

RIT Institutional Review Board for the
Protection of Human Subjects in Research
141 Lomb Memorial Drive
Rochester, New York 14623-5604
Phone: 585-475-7673
Fax: 585-475-7990
Email: hmfsrs@rit.edu

Form C
IRB Decision Form

TO: Brendan Parker; Anne Haake

FROM: RIT Institutional Review Board

DATE: **4/30/09**

RE: **Decision of the RIT Institutional Review Board**

Project Title – Assessing Interpretability of Visual Symbols of Varying Colors Across Demographic Profiles

The Institutional Review Board (IRB) has taken the following action on your project named above.

☒ Approved, no greater than minimal risk

Now that your project is approved, you may proceed as you described in the Form A. **Note that this approval is only for a maximum of 12 months; you may conduct research on human subjects only between the date of this letter and 4/30/10.**

You are required to submit to the IRB any:

- **Proposed** modifications and wait for approval before implementing them,
- Unanticipated risks, and
- Actual injury to human subjects.

Return the Form F, at the end of your human research project or 12 months from the above date. If your project will extend more than 12 months, your project must receive continuing review by the IRB.

Heather Foti
Associate Director, Office of Human Subjects Research

Revised 10-18-06

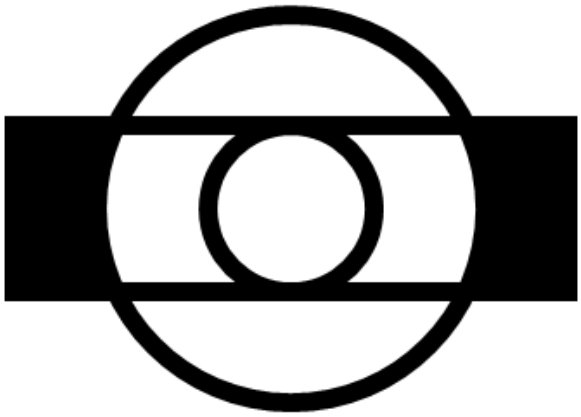
Appendix G – Advertisement Methods

To promote the experiment and increase the number of participants, advertisement was necessary. The ads targeted the intended demographics and highlighted the incentive prize of a $15 gift certificate to Barnes and Noble. Below are some of the advertisement methods used.

Posters:

Posters were hung around RIT and some neighboring buildings. The posters featured an icon that was not used in the experiment and a statement explaining the incentive prize. Each poster had tabs at the bottom which were cut. People passing by could tear off a tab to take with them. Each tab contained information about the study and the website address where it was featured. People apparently noticed the posters, as some students answered with their interpretations on the posters themselves.

What does this icon represent?



Answer for a chance to win $15 at www.iconstudy.com

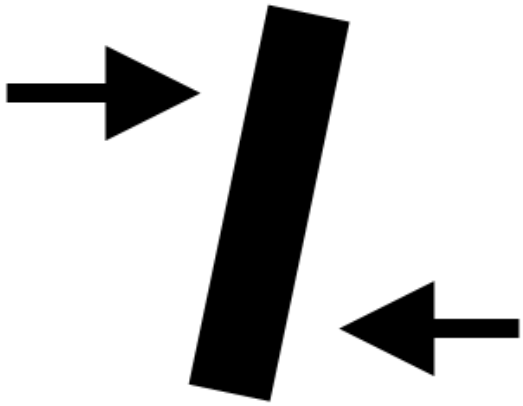
Participate in a fun online icon interpretation survey and you will have a chance to win a $15 gift certificate to Barnes and Noble!

This study is being conducted for completion of a Master's thesis in Information Technology at the Rochester Institute of Technology. Your answers will help us discover better practices for designing icons and symbols.

Participate for a chance to win $15 at **www.iconstudy.com**

Participate for a chance to win $15 at **www.iconstudy.com**
Participate for a chance to win $15 at **www.iconstudy.com**
Participate for a chance to win $15 at **www.iconstudy.com**
Participate for a chance to win $15 at **www.iconstudy.com**
Participate for a chance to win $15 at **www.iconstudy.com**
Participate for a chance to win $15 at **www.iconstudy.com**
Participate for a chance to win $15 at **www.iconstudy.com**

What does this icon represent?



Answer for a chance to win $15 at www.iconstudy.com

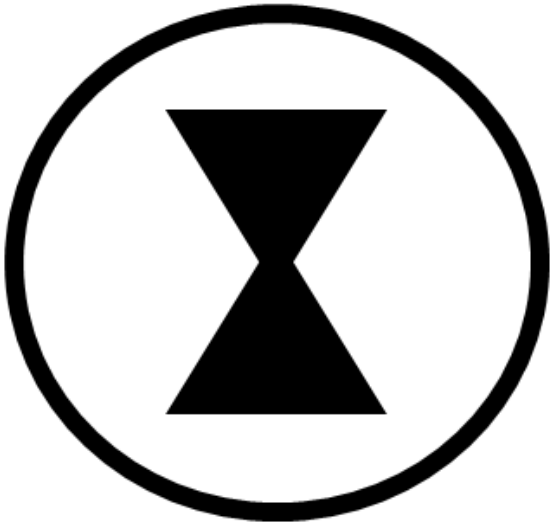
Participate in a fun online icon interpretation survey and you will have a chance to win a $15 gift certificate to Barnes and Noble!

This study is being conducted for completion of a Master's thesis in Information Technology at the Rochester Institute of Technology. Your answers will help us discover better practices for designing icons and symbols.

Participate for a chance to win $15 at www.iconstudy.com

Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com

What does this icon represent?



Answer for a chance to win $15 at www.iconstudy.com

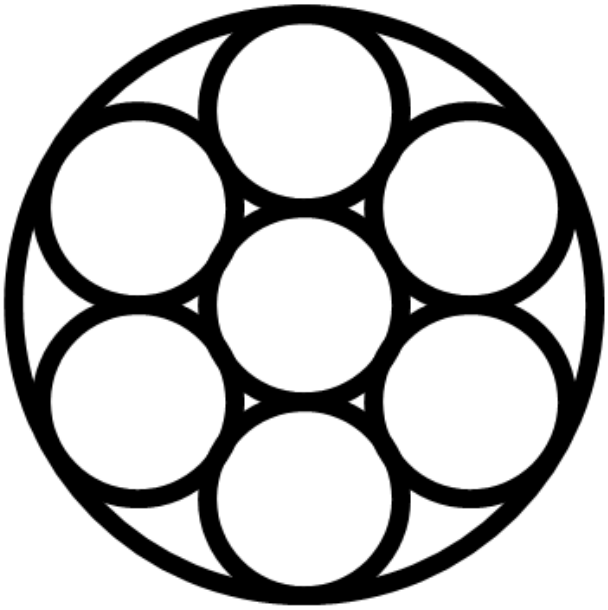
Participate in a fun online icon interpretation survey and you will have a chance to win a $15 gift certificate to Barnes and Noble!

This study is being conducted for completion of a Master's thesis in Information Technology at the Rochester Institute of Technology. Your answers will help us discover better practices for designing icons and symbols.

Participate for a chance to win $15 at www.iconstudy.com

Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com

What does this icon represent?



Answer for a chance to win $15 at www.iconstudy.com

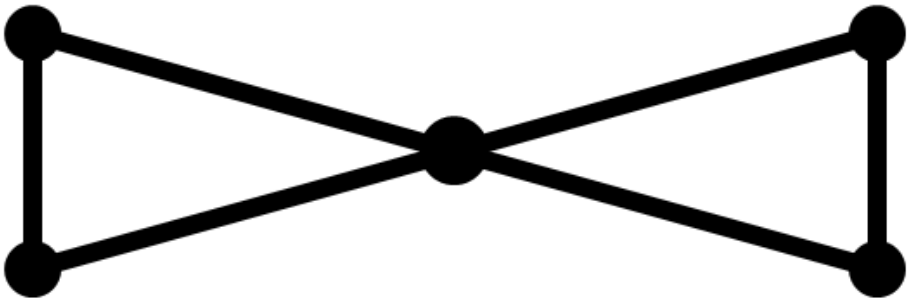
Participate in a fun online icon interpretation survey and you will have a chance to win a $15 gift certificate to Barnes and Noble!

This study is being conducted for completion of a Master's thesis in Information Technology at the Rochester Institute of Technology. Your answers will help us discover better practices for designing icons and symbols.

Participate for a chance to win $15 at www.iconstudy.com

Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com

What does this icon represent?



Answer for a chance to win $15 at www.iconstudy.com

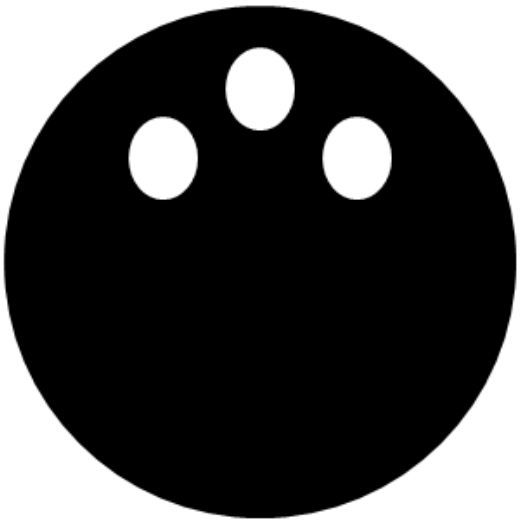
Participate in a fun online icon interpretation survey and you will have a chance to win a $15 gift certificate to Barnes and Noble!

This study is being conducted for completion of a Master's thesis in Information Technology at the Rochester Institute of Technology. Your answers will help us discover better practices for designing icons and symbols.

Participate for a chance to win $15 at www.iconstudy.com

Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com

What does this icon represent?



Answer for a chance to win $15 at www.iconstudy.com

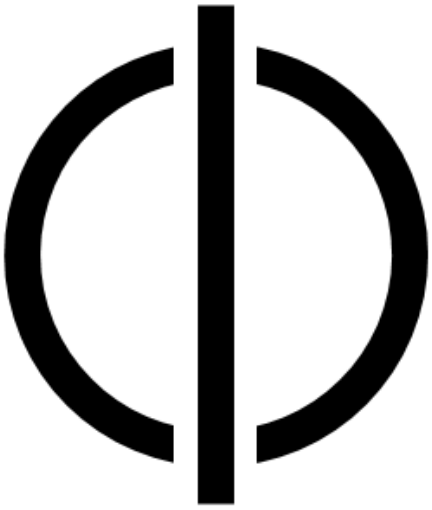
Participate in a fun online icon interpretation survey and you will have a chance to win a $15 gift certificate to Barnes and Noble!

This study is being conducted for completion of a Master's thesis in Information Technology at the Rochester Institute of Technology. Your answers will help us discover better practices for designing icons and symbols.

Participate for a chance to win $15 at www.iconstudy.com

Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com

What does this icon represent?



Answer for a chance to win $15 at www.iconstudy.com

Participate in a fun online icon interpretation survey and you will have a chance to win a $15 gift certificate to Barnes and Noble!

This study is being conducted for completion of a Master's thesis in Information Technology at the Rochester Institute of Technology. Your answers will help us discover better practices for designing icons and symbols.

Participate for a chance to win $15 at www.iconstudy.com

Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com

What does this icon represent?

Answer for a chance to win $15 at www.iconstudy.com

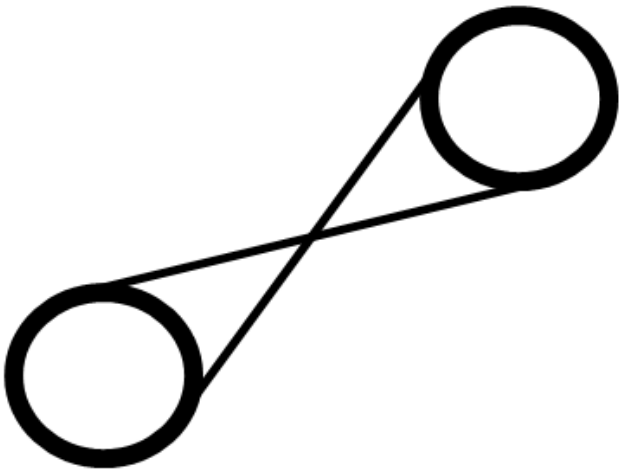
Participate in a fun online icon interpretation survey and you will have a chance to win a $15 gift certificate to Barnes and Noble!

This study is being conducted for completion of a Master's thesis in Information Technology at the Rochester Institute of Technology. Your answers will help us discover better practices for designing icons and symbols.

Participate for a chance to win $15 at www.iconstudy.com

Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com

What does this icon represent?



Answer for a chance to win $15 at www.iconstudy.com

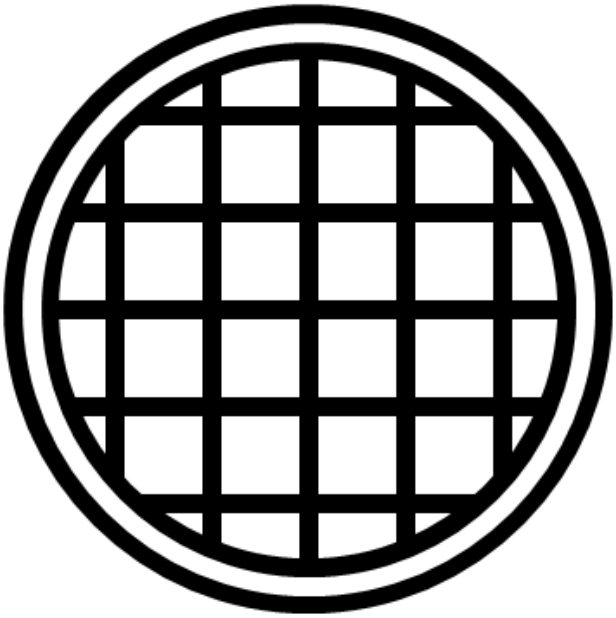
Participate in a fun online icon interpretation survey and you will have a chance to win a $15 gift certificate to Barnes and Noble!

This study is being conducted for completion of a Master's thesis in Information Technology at the Rochester Institute of Technology. Your answers will help us discover better practices for designing icons and symbols.

Participate for a chance to win $15 at **www.iconstudy.com**

Participate for a chance to win $15 at **www.iconstudy.com**
Participate for a chance to win $15 at **www.iconstudy.com**
Participate for a chance to win $15 at **www.iconstudy.com**
Participate for a chance to win $15 at **www.iconstudy.com**
Participate for a chance to win $15 at **www.iconstudy.com**
Participate for a chance to win $15 at **www.iconstudy.com**
Participate for a chance to win $15 at **www.iconstudy.com**

What does this icon represent?



Answer for a chance to win $15 at www.iconstudy.com

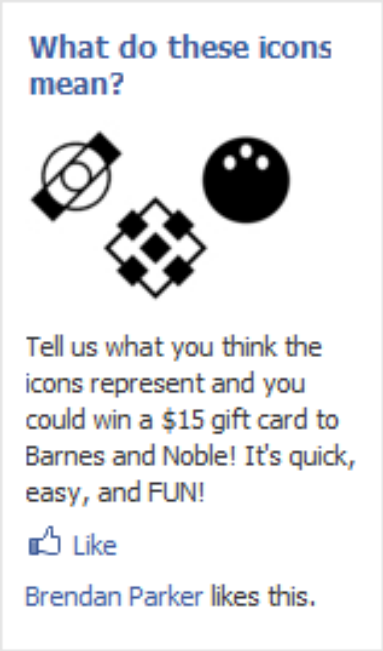
Participate in a fun online icon interpretation survey and you will have a chance to win a $15 gift certificate to Barnes and Noble!

This study is being conducted for completion of a Master's thesis in Information Technology at the Rochester Institute of Technology. Your answers will help us discover better practices for designing icons and symbols.

Participate for a chance to win $15 at www.iconstudy.com

Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com
Participate for a chance to win $15 at www.iconstudy.com

Facebook Ads:



What do these icons mean? Tell us what you think certain icons represent and you could win a $15 gift card to Barnes and Noble! It's quick, easy, and fun!

The Facebook ad was 160 x 270 px. The ad was supposed to facilitate clicks by attracting potential participants. The text and images were meant to add appeal to the advertisement. The images used in the ad were not images from the experiment, so as not to affect the results.

RIT Mailer

This email message was sent to all active IT students and faculty inviting them to participate in the online survey. This is suspected to be the most effective advertisement means.

Need Participants for RIT Online Icon Identification Study

Take a short, fun icon identification survey at www.iconstudy.com, and you will have a chance to win a $15 gift certificate to Barnes and Noble by telling us what you think certain icons represent. This legitimate scientific study is a usability analysis on icons and should take about 10 minutes to complete. This survey is being conducted through RIT as part of the completion of a Master's of Science degree.

Post to Forums and Message Boards

Need Participants for Online Icon Study (You can win $15)

Would you like to take a fun icon identification survey? At www.iconstudy.com, you can win a $15 gift certificate to Barnes and Noble by telling us what you think certain icons represent. This is a fun online survey that should take only 10 – 15 minutes to complete. Your participation would certainly help us reach our goal.

This survey is being conducted through the Rochester Institute of Technology in Rochester, NY as part of the completion of a Master's of Science degree. This legitimate scientific study is a usability analysis on icons. After analyzing the data, we expect to have a better idea of how to appropriately design icons for maximum effectiveness.

Icons are important tools for expressing the functions of certain parts of the interface. They assist in the communication between the human and the interface. Icons are a universal language, interpretable by people from all cultures and backgrounds. Though icons are an important and effective means of communication between a user and interface, they must be appropriately designed to function as they should. Many icons are ambiguous, causing confusion and miscommunication.

If you would like to participate, please visit www.iconstudy.com. If you complete the survey, you will be entered into a raffle to win a $15 gift certificate to Barnes and Noble.

Thank you very much.

info@iconstudy.com

Table of Elements

Figures

Graphs

Tables

Sources

Works Cited

[1] Adobe. (2005). Illustrator (Version CS2) [Computer software]. Adobe.

[2] Agresti, A. (1990). *Wiley series in probability and mathematical statistics: Categorical data analysis* (pp. 14-17, 306-317). New York: John Wiley & Sons.

[3] Andrews, M., & Whittaker, J. A. (2006). *How to break web software: Functional and security testing of web applications and web services*. Boston, MA: Pearson Education.

[4] Bates, K. F. (1949). *Basic design: Principles & practice*. New York: Barnes & Noble Books.

[5] Bias, R. G., & Mayhew, D. J. (2005). *Cost-justifying usability: An update for the internet age* (2nd ed., pp. 19, 56, 188, 274-276). San Francisco: Morgan Kaufmann.

[6] Birren, F. (1978). *Color & human response: Aspects of light and color bearing on the reactions of living things and the welfare of human beings* (pp. 13-25, 52-65). New York: Van Nostrand Reinhold Company.

[7] Birren, F. (1992). *Color psychology and color therapy* (pp. 142-144, 179-181, 181-183, 257-261). New York: First Carol Publishing Group.

[8] Brace, I. (2004). *Questionnaire design: How to plan, structure and write survey material for effective market research* (pp. 86-89). London: Kogan Page.

[9] Brimar Industries. (2010). *Safetysign.com*. Retrieved February 10, 2010, from http://www.safetysign.com/Safety+Labels/ISO+Hazard+Alert+Symbol+Labels/J6538/2858.html

[10] Campbell, D. T., & Stanley, J. C. (1963). *Experimental and quasi-experimental designs for research* (pp. 6, 25-27). Chicago: Rand McNally College Publishing Company.

[11] Carnegie Mellon. (2008). ESP Game [Computer program]. Retrieved October 3, 2008, from http://www.gwap.com/gwap/gamesPreview/espgame/

[12] Carraher, R. G., & Thurston, J. B. (1966). *Optical illusions and the visual arts* (p. 12). New York: Litton Educational.

[13] Castro, C., & Horberry, T. (2004). *The human factors of transport signs* (pp. 19, 42-46, 77-78, 116-117, 121). New York: CRC Press.

[14] Conway, B. R. (2002). *Neural mechanisms of color vision* (pp. 1-6). Norwell, MA: Kluwer Academic.

[15] Deręgowski, J. B. (1984). *Distortion in art* (p. 22). London: Routledge & Kegan Paul.

[16] Dondis, D. A. (1973). *Primer of visual literacy* (p. 72). Cambridge: Massachusetts Institute of Technology.

[17] Dreyfuss, H. (1972). *Symbol sourcebook* (pp. 26-31, 48-53, 80-85, 98-99, 140, 208-209). New York: McGraw-Hill. (Original work published 1984.)

[18] Edelman, S. (1999). The problem of representation. In *Representation and recognition in vision* (pp. 1-10). Cambridge, Massachusetts: Massachusetts Institute of Technology.

[19] *Eye movements*. (2004). Retrieved July 20, 2008, from Rochester Institute of Technology Visual Perceptions Library website: http://www.cis.rit.edu/vpl/eye_movements.html

[20] *Facebook*. (n.d.). Retrieved August 12, 2009, from http://www.facebook.com

[21] Fischler, M. A., & Firschein, O. (1987). The nerve cell and nervous system organization. In *Intelligence: The eye, the brain, and the computer* (pp. 58-60). Addison-Wesley.

[22] Fleming, J. (1998). *Web navigation: Designing the user experience* (pp. 70-71). Sebastopol, CA: O'Reilly & Associates.

[23] Games for the Brain. (n.d.). Image Quiz [Computer program]. Retrieved October 1, 2008, from http://www.gamesforthebrain.com/game/imagequiz/

[24] The gestalt principles. (n.d.). *Spokane Falls Community College*. Retrieved July, 2008, from http://graphicdesign.spokanefalls.edu/tutorials/process/gestaltprinciples/gestaltprinc.htm

[25] Go. (2008). In *The Columbia encyclopedia*. Retrieved from http://www.credoreference.com/entry/8272798/

[26] Google Image Labeler [Computer program]. (2007). Retrieved October 5, 2008, from http://images.google.com/imagelabeler/

[27] Greene, M. R., & Oliva, A. (2008, August 30). Recognition of natural scenes from global properties: Seeing the forest without representing the trees. *Cognitive Psychology, 58*(2), 137-176. doi:10.1016/j.cogpsych.2008.06.001

[28] Hamilton, A. (2000, November). Metaphor in theory and practice: The influence of metaphors on expectations. *ACM Journal of Computer Documentation, 24*(4), 237-253. doi:10.1145/353927.353935

[29] Horton, W. (1994). *The icon book: Visual symbols for computer systems and documentation* (pp. 262, 245, 249, 260). Toronto: John Wiley & Sons.

[30] Horton, W. (1996). Designing icons and visual symbols. *Conference on Human Factors in Computing Systems*, 371 - 372. doi:10.1145/257089.257378

[31] Hutchins, E. L., Hollan, J. D., & Norman, D. A. (1986). Direct maniulation interfaces. In D. A. Norman & S. W. Draper (Eds.), *User centered system design: New perspectives on human-computer interaction* (pp. 87-124). Hillsdale, New Jersey: Lawrence Erlbaum Associates.

[32] Ishihara, S. (1970). *Ishihara's test for colour-blindness: Concise edition* (pp. 1-6). Tokyo: Isshinkai.

[33] Jacobs, G. H. (1981). *Comparative color vision* (pp. 23-32). New York: Academic Press.

[34] Kay, A. (2006). The early history of smalltalk. In *Smalltalk.org* (p. 22). Retrieved May 30, 2008, from http://www.smalltalk.org/downloads/papers/SmalltalkHistoryHOPL.pdf

[35] Kim, J. H., & Lee, K. P. (2005). Cultural difference and mobile phone interface design: Icon recognition according to level of abstraction. *ACM International Conference Proceeding Series, 111*, 307-310. doi:10.1145/1085777.1085841

[36] Kucer, S. B. (2005). *Dimensions of literacy* (pp. 35-38, 264). Mahwah, New Jersey: Lawrence Erlbaum Associates.

[37] Landauer, T. K., Foltz, P. W., & Laham, D. (1998). Introduction to latent semantic analysis. *Discourse Processes, 25*, 259-284. Retrieved from http://lsa.colorado.edu/papers/dp1.LSAintro.pdf

[38] Lightbown, P. M., & Spada, N. (2006). *How languages are learned* (3rd ed.) (pp. 15-17). New York: Oxford University Press.

[39] Lindsay, P. H., & Norman, D. A. (1977). *Human information processing: An introduction to psychology* (2nd ed., pp. 56-82, 113). New York: Academic Press.

[40] Malacara, D. (2002). *Color vision and colorimetry* (pp. 1-17). Bellingham, Washington: Spie Press.

[41] Marcus, A. (2003). Icons, symbols, and signs: Visible languages to facilitate communication. *Interactions, 10*(3), 37-43. doi:10.1145/769759.769774

[42] Martinez, B., & Block, J. (1988). *Visual forces: An introduction to design*. Englewood Cliffs, New Jersey: Prentice Hall.

[43] Massironi, M. (2002). *The psychology of graphic images: Seeing, drawing, communicating* (N. Bruno, Trans., pp. 62-64, 71-77, 141-177, 196-211, 216-221, 223-235, 260-264). Mahwah, New Jersey: Lawrence Welbaum Associates. (Original work published 1937)

[44] Miller, A. R., Brown, J. M., & Cullen, C. D. (2000). *Global graphics: Symbols* (p. 49). Gloucester, Massachusetts: Rockport.

[45] Moggridge, B. (2007). *Designing interactions* (pp. 15-72, 244-249). Cambridge, MA: MIT Press.

[46] Newton, N. (1995). How do we understand a symbol? *Proceedings of the Conference on Representation: Relationship Between Language and Image*, 91-96. Retrieved from http://portal.acm.org.ezproxy.rit.edu/citation.cfm?id=212061.212074&coll=Portal&dl=GUIDE&CFID=3502710&CFTOKEN=35825378

[47] Nielsen, J. (2005). How to conduct a heuristic evaluation. In *Useit.com*. Retrieved May 12, 2008, from http://www.useit.com/papers/heuristic/heuristic_evaluation.html

[48] Nielsen, J. (2005). Ten usability heuristics. In *Useit.com: Usable information technology*. Retrieved April 13, 2009, from http://www.useit.com/papers/heuristic/heuristic_list.html

[49] Norman, D. A., & Rumelhart, D. E. (1975). Aspects of human problem solving: The use of internal representation. In *Explorations in cognition* (pp. 308-346). San Francisco: W. H. Freeedman and Company.

[50] Parkin, A. J. (2000). *Essential cognitive psychology* (pp. 113-114). New York: Psychology Press. (Original work published 2000)

[51] Robinson, G. (2008). Guess-the-google [Computer program]. Retrieved September 26, 2008, from http://grant.robinson.name/projects/guess-the-google/

[52] Roshal, A. (2008). WinRAR (Version 3.80) [Computer software]. Retrieved April 20, 2009, from http://www.rarlab.com

[53] Rousseau, L. (2008). Color. In D. Millman, *The essential principles of graphic design* (pp. 14-16). Cincinnati, Ohio: F+W Publications.

[54] *SAS work shop* [Categorical data procedures]. (n.d.). Retrieved December 12, 2009, from University of Idaho website: http://www.uiweb.uidaho.edu/ag/statprog/sas/workshops/catmod/handout5_cat.pdf

[55] Sharpe, D. T. (1981). *The psychology of color and design* (p. 8). Totowa, New Jersey: Littlefield Adams. (Original work published 1975)

[56] Stone, D., Jarrett, C., Woodroffe, M., & Minocha, S. (2005). Inspections of the user interface. In *User interface design and evaluation* (pp. 525-537). San Francisco: Morgan Kaufmann.

[57] Straub, K., Ph.D. (2003, September). Pitting usability testing against heuristic review. In *Human Factors International*. Retrieved May 11, 2008, from http://www.humanfactors.com/downloads/sep03.asp

[58] Stroop, J. R. (1935). Classics in the history of psychology. *Journal of Experimental Psychology, 18*, 643-662. Retrieved from http://psychclassics.yorku.ca/Stroop/

[59] Sullivan, L. H. (1970). *Kindergarten chats on architecture, education, and democracy [Microfiche]* (pp. 36-45). Library Resources. (Original work published 1901.)

[60] Tesler, L. (1981, August). The smalltalk environment. *Byte*, sec. 9. Retrieved from CMP Media, LLC website: http://www.byte.com/art/9608/sec4/art3.htm

[61] VanDoorn, A. J., VanDeGrind, W. A., & Koenderink, J. J. (1984). *Limits in perception* (pp. 323-358). Utrecht, The Netherlands: VNU Science Press BV.

[62] Wang, H. F. (2007). Are icons used in existing computer interfaces obstacles to Taiwanese computer users? *ACM International Conference Proceeding Series, 250*, 199-202. doi:10.1145/1362550.1362590

[63] *World wide web consortium*. (2008). Retrieved March 11, 2009, from http://www.w3.org/

[64] *World Wildlife Fund*. (2006). Retrieved June 8, 2008, from http://www.wwf.org/